SURGERY, GYNECOLOGY AND OBSTETRICS

AN INTERNATIONAL MAGAZINE, PUBLISHED MONTHLY

VOLUME LI SEPTEMBER, 1930 NUMBER 3

PRINCIPLES OF THE TREATMENT OF NON-UNION OF FRACTURE

FRED H. ALBEE, M.D., SC.D., F.A.C.S., NEW YORK

NATURE OF UNION AND NON-UNION

BONE is a connective tissue which contains specialized cells, the osteoblasts, capable of depositing, or causing the deposition of, certain lime salts. Re-union of bone fragments after fracture therefore entails, first, the same mechanism as the re-union of connective tissue fragments, and, second, the deposition of lime salts to make the union solid.

When connective tissue is severed without laceration and the two surfaces are exactly replaced, it is possible for union to occur purely by re-union of severed fibroblastic processes and proliferation of fibroblasts. This is strictly union by first intention. Actually union by first intention differs from any other union only in degree, since practically all union is brought about by granulation tissue. It is generally believed that injured serous surfaces may be united by adhesion (by means of coagulation of lymph) and subsequent proliferation of fibroblasts. In most cases, however, such union is promoted by the formation of granulation tissue.

The process of union is thus instituted by two elements, the blood vessels and the fibroblasts. When a small blood vessel, after being severed, clots and ceases to function in its distal portion, a capillary bud or sprout grows out from the active portion to carry the circulation around the obstacle. The same process is going on on the other side of the wound. The fibroblasts meet the situation by a similar increase in activity. Severed cells are reconnected and produce new fibrous processes. The process continues: the capillary loops after reaching the surface of the wound continue sprouting; the fibroblasts multiply and send out more fibers between the loops of capillaries. The removal of the clot and débris from lacerated cells goes on at the same time. Finally, depending on the width of the gap and the speed of granulation, the new tissue from opposite sides meets and merges, the capillary loops anastomosing to form continuous vessels from one side of the wound to the other.

There is recognizable in this stimulation of growth some unknown factor which compels severed tissues to complete themselves. John Hunter called it the "stimulus of incompleteness." Severed and separated tissues will not only repair themselves but they will push out new tissue, of two varieties, in the effort to restore continuity.

After closure of the wound, the granulation tissue contracts and its vessels gradually disappear until only the comparatively avascular scar tissue is left. This marked difference between highly vascular granulation tissue and almost bloodless scar tissue has an important bearing on non-union of fracture, as will appear presently.

Non-union of wounds can occur in soft tissue as well as in bone. If two surfaces are

kept apart, as by purulent discharge in sinuses for instance, non-union may come to be almost as fixed a state as non-union in bone. The two surfaces become covered with dense scar which forms an effective barrier to granulation, being the end-result of previous ineffective granulation tissue formation. In these cases, the attempt to establish a bridge by means of vascular sprouts having failed and further attempt being checked by the limiting avascular membrane, the "stimulus of incompleteness" is turned inward on itself: the new capillaries form loops with each other to establish venous and arterial connections and become reconciled to the situation. The vascular system under the limiting scar is as complete and settled as it is under the normal epidermis. In order to grasp the analogy between this state and non-union of bone, one must realize that the ununited surfaces of the sinus are separated not so much by pus and scar tissue as by the lack of the stimulus of incompleteness, since completeness of a kind has been attained and accepted as final. Union will not occur until vascular continuity has again been broken and stimulus of incompleteness again set up. In surgical language, the wound is freshened until it bleeds.

The first stage in the union of fracture is identical with the union of soft tissue just described. Hæmorrhage and coagulation between the fragments and thrombosis of the severed vessels are followed by capillary sprouting and fibroblastic proliferation to form granulations which push out until they meet.

The only difference between granulation tissue here and elsewhere is that in the bone the granulations contain the special cells, the osteoblasts. Their origin is a matter of perhaps not very serious debate. Dieterich's opinion is that they are a product of the germinal perivascular tissue. Only functionally fresh undifferentiated cells in connection with the rapidly budding capillaries could, in his opinion, be expected to work so rapidly. He thus ignores the "osteogenic" layer of the endosteum and the periosteum and points to the capillaries budding from the old blood vessels as the important factor in the regeneration of bone.

The next stages in the union of bone are peculiar to bone, and are largely concerned with the activities of the osteoblasts. The pre-osseous substance is probably secreted by them; the precipitation of calcium phosphate and carbonate in this substance transforms it into bone. The deposits are in the form of trabeculæ, with the blood vessels in the canals between them. In Blaisdell and Cowan's experiments, the blood clot had been replaced by a cellular and vascular growth on the fifth day; by the tenth day, callus was abundant and showed ossification with transverse trabeculæ.

According to Bancroft and others the vessels of the bridging callus grow in from the medulla and periosteum, so that the new haversian canals run at right angles to the shaft. The source of the new circulation is, therefore, partly the marrow and partly the periosteum and the muscles which normally supply it with circulation or, as a sequel to the trauma causing the fracture, establish vascular connections with it. In the favorable case, these two systems of new vessels unite and carry first a vascular and fibrous bridge and finally a solid bony one across the gap. The rearrangement of the circulation and realignment of haversian canals are carried out gradually.

The exuberant callus that is laid down around the site of fracture and even in neighboring lacerated tissues is formed in the same way. Everywhere the injured vessels form granulation tissue which is rapidly impregnated with osseous material. When healing is completed, much of this excess callus gradually disappears, the lime salts and the granulation tissue being absorbed.

The transverse arrangement of haversian canals referred to by Bancroft is eventually changed to a longitudinal one. The ultimate structure of the calloused area must be similar to that of the original fragments, since it is determined by the stress in the same region. Thus the trabeculæ come to present an orderly arrangement with continuous haversian canals traversing the zone where callus was originally laid down. This necessitates, and is probably in part dependent on, rearrangement of the vessels, the transverse system of

vessels in the primary callus being replaced by longitudinal haversian vessels. Restoration is not complete until the callus has assumed this orderly structure in anatomical and mechanical harmony with the rest of the bone. Until this has occurred the new structure is not completely suited to its function; and it may give way before undue strain which the fully restored structure would withstand. This, I believe, accounts for the absorption of bone occasionally observed after union has become apparently solid: X-ray examination would show that restoration has not been complete and that absorption would be avoided by proper support and braceage.

The process of union thus consists of four overlapping stages: (1) preliminary fibrous union (granulation tissue); (2) formation of soft callus; (3) formation of hard callus; (4) adaptive reconstruction of the callus.

Of these stages, only the first is clear, and even that is not always considered. Callus is often regarded as a sort of glue which is exuded, like gum from a tree, and eventually hardens into bone. The complexity of the process can be grasped only after consideration of the functions of bone and their interrelationship with other bodily functions.

The metabolic function of bone. While Leriche and Policard may have overstated the fact in asserting that the primary function of bone is to store calcium, they are undoubtedly right in considering that function among the most important in the economy of the body. The calcium concentration in the blood is maintained within narrow limits; elevation or depression of it beyond a definite range is not compatible with life. Since removal of the parathyroids decreases the amount of calcium in the blood and causes tetany and death, and since injection of the parathyroid principle causes increase in the blood content of calcium, it is reasonable to suppose that the parathyroids govern the calcium level in the blood, and that they are in health always active. It would follow that calcium is being constantly either released into or absorbed from the blood stream, in a manner analogous to that in which sugar is released or stored by the liver. The calcium salts in bone must therefore be regarded as existing in the solid phase under chemical conditions which can be readily and quickly reversed to produce the soluble phase. In bone, the calcium is present as calcium phosphate and calcium carbonate. In the blood, the calcium has been shown to exist in different states, partly ionized; some of it is believed to be united with protein. The phosphate in the blood probably exists in organic form as a hexose-monophosphoric ester. In connection with the investigation of this and similar substances *in vitro*, Robison found in growing bone, and in certain other tissues, an enzyme capable of hydrolyzing the organic phosphoric acid and releasing the inorganic radical. The enzyme acted also on glycerophosphoric ester.

Two striking facts appeared from these investigations by Robison and his co-workers (10, 12, 13): the enzyme requires an alkaline medium and the curve of activity shows a marked rise around a hydrogen-ion concentration of 8.4; and the enzyme can bring about a reverse reaction, synthesis of the organic acid, under certain conditions. The enzyme, now known as phosphatase, is supposed to be secreted by the osteoblasts in the bone; how it is derived in other tissues has not been suggested. It would appear that there must be some agent in growing bone capable of producing in the fluid medium in the bone a hydrogen-ion concentration considerably higher than that in the blood or in any other normal tissue, so far as is known. The determination of the actual hydrogen-ion concentration in tissue juice presents great difficulties. Robison and Soames (13) suggest that the osteoblasts can produce a local elevation of hydrogen-ion concentration. The hydrogen-ion concentration must be considered, however, from the point of view both of its direct effect on the activity of the enzyme and its indirect effect through the solubility of the products of hydrolysis. The optimal hydrogen-ion concentration in the body might be considerably lower than that *in vitro* if the precipitation of the inorganic phosphate could be accelerated by some compensating means, such as the maintenance, by the osteoblast, of a high concentration of calcium ions in the tissue juices of bone. The product of the

concentrations of the calcium and phosphate would thus come to exceed the solubility product of calcium phosphate and precipitation would occur. Calcification would thus be the result of the co-operative action of phosphatase and the osteoblast, the former determining the concentration of the phosphate and the latter the concentration of the calcium ions.

The discovery by Martland and Robison of the synthetic action of the enzyme is of equal interest. If an excess of glycerol or glucose (or one of several similar substances) is added to the test tube after hydrolysis has gone on and inorganic phosphate has been precipitated, the phosphate passes again into solution to form the organic phosphoric ester. From this experiment it may be inferred that, in the body, an excess of some such substance as glucose in the tissue juice of the bone will cause the absorption of bone salts under the influence of the enzyme. If the determination of this local increase in glucose, as well as of the alternative local increase in calcium ions, may be attributed to the osteoblasts, the alternating deposition and absorption of bone salts can be attributed to two different activities of the osteoblast, while the activity of the enzyme is determined by the purely chemical conditions as they are thus altered by the osteoblast. The governing mechanism of the osteoblast in such assumed concentration of glucose and calcium is speculative; but it may be centered in the parathyroids. If the parathyroid principle could cause the osteoblasts to increase the glucose in the tissue juice of the bone, phosphate and calcium would pass into solution; if it could prohibit the calcium concentrating function of the osteoblasts, no phosphate would be precipitated.

Robison's investigations were carried out for the purpose of determining the chemical reactions concerned in the ossification of young bone, and the conditions under which these reactions occur. They may be equally applicable to the metabolism of calcium and phosphorus as it is continually carried on. The association of calcium with protein, and of phosphorus with carbohydrate, in the blood illustrates again how interdependent the bodily elements are in their metabolism. These considerations reveal bone as not only a complicated organ but essential to life like the liver or kidneys.

Robison makes no reference to any such possible function of phosphatase. Kay, one of Robison's co-workers, suggested that the purpose of the phosphatase in older bones "may be part of a protective mechanism, ensuring that throughout the whole life of the animal there is a slight excess of PO_4 ions in the neighborhood of the already deposited bone, so that inorganic phosphorus does not go again into solution." This statement is not in accord with the established fact that calcium (and therefore phosphate) is continually passing into and out of solution. Kay's statement was made before Robison demonstrated the reversibility of the phosphatase action.

The presence of phosphatase in the kidney has an important bearing on the argument. Its concentration in that organ is almost of the same order as that in bone, in contrast to the low concentration in other organs and tissues. It has been suggested by Robison's group that here the phosphatases is concerned in the elimination of calcium from the blood. If it thus has a constant function, in the kidney, related to the metabolism of calcium, it is not unreasonable to attribute to it some corresponding or complementary function in bone.

The dependence of bone metabolism, or at least bone growth, on the activities of other organs is even further from explanation. The thymus, testicle and ovary, thyroid and pituitary all affect growth or ossification of bones or calcium metabolism. It may be assumed that the effect is produced indirectly.

So far as I have been able to ascertain, Robison's investigations have not been carried out on fractured bone. Some of his early work (12), however, is applicable to fracture. A long bone from a freshly killed rachitic animal was cut in two longitudinally. One-half was incubated, as a control, in normal saline, the other in a solution of calcium hexosephosphate. In the control, the osteoid substance thrown out by the cut surface contained no lime salts on histological examination. In the other half, dense deposits of calcium salts were found in the osteoid. Robison used this exper-

iment to demonstrate the hydrolytic effect of phosphatase on the organic soluble phosphate. Since he has found no less phosphatase in rachitic than in normal bone, he assumed that the rachitic manifestations were attributable to some failure of the supply of organic phosphate. His conclusions in this regard have no immediate reference to the subject of this paper. It will be observed, however, that Robison had produced conditions which do not obtain normally: he was experimenting with traumatized bone; and neither at that time nor in a later experiment (13) did he have a non-rachitic traumatized bone as a control. The experiment may equally well be used to demonstrate the ability of the osteoblasts and phosphatase to calcify callus in a traumatized bone, provided there is an ample supply of the substrate. It will also be observed incidentally that, in the experiment, the bone is cut off from the direct influence of the parathyroids. Robison's results may fairly be applied to the reaction of bone after fracture: if the supply of the substrate is maintained (by adequate blood supply), the callus will calcify; if circulation is defective it will not; and the positive effect requires the presence of phosphatase. The further application of the experiment to the behavior of the bone graft is interesting if not yet quite justifiable. It constitutes, at any rate, a partial refutation of the contention that a bone graft dies and is absorbed, and it supports the argument, which I shall presently advance, that speedy establishment of vascular connection with the graft is essential to the proper supply of the soluble phosphate (and calcium) necessary to consolidation of the union of graft and host.

It is not too much to assume that the deposition of lime salts in the granulation tissue at the line of fracture is controlled by the same mechanism that brings about ossification in a young bone.[1] It is true that the amount of phosphatase decreases after developmental ossification is complete, but the newly formed osteoblasts in healing bone, whether produced by proliferation of those of neighboring bone or by metaplasia of fibroblasts, might be expected to possess increased potentiality for the manufacture of phosphatase. At any rate, it is more reasonable to believe that the increased osteogenetic potentiality of bone after fracture consists of increased manufacture of phosphatase, both for hydrolysis and synthesis, than to attribute it to the much debated increase in the calcium and phosphorus content of the blood. Increase in these elements, if it does occur, loses much of its importance when considered with the complex processes of bone metabolism.

The calcium phosphate and carbonate are laid down in the pre-osseous substance, presumably under the influence of the phosphatase, under chemical conditions governed by the osteoblast. Whether the lines of stress produce a pattern in the pre-osseous substance, as Leriche and Policard suggest, whether the law of colloids under pressure is applicable, or whether stress has a direct effect upon the action of the osteoblast, the result is that the new bone is laid down in trabecular formation, leaving the vessels in canals at right angles to the axis of the bone. Robinson (11) considers that the formation of trabeculæ depends upon the accidental arrangement of the vessels of the callus. Whether this is so or not, the rearrangement of the trabeculæ to conform to the stresses of function cannot be explained so simply. It would not help the argument to endow the vessels with adaptability to stress. Whatever the fundamental explanation, this rearrangement of trabecular structure must be immediately effected by the osteolytic and precipitating activity of phosphatase following changes in the constitution of the substrate in adjoining zones of bone either synchronously or at alternating intervals. It is futile to expect at this time to translate into terms of chemistry these reactions of living tissue to environment.

Non-union of fracture. Theoretically, non-union might result from the failure of any one of the stages of union; practically union is more likely to fail at some stages than at others.

1. The granulation tissue may fail to bridge the gap: (a) because of the interposition of tissue which the granulations cannot

[1] In conjunction with the Biochemical Laboratory of the New York Post Graduate Medical School, I have undertaken the investigation of the concentration of phosphatase in bony material derived from cases of fracture and of non-union.

penetrate; (b) because the fragments are so displaced that the two areas of granulation cannot meet; (c) because too extensive removal of blocks of living bone after fracture has left the fracture surfaces too far apart.

2. The granulation tissue may degenerate into scar tissue before ossification has been established. If the formation of the granulation tissue is slow and its nutrition is not well maintained, the stage of contraction is likely to be precipitated. The osteoblasts under such circumstances are poorly nourished, and they multiply slowly and secrete pre-osseous substance and phosphatase slowly; sufficient lime salts cannot be deposited to bridge the gap before the stage of contraction of the granulation tissue sets in.

3. The early granulation tissue may be so disrupted by manipulation, or inadequate immobilization and the stress exerted on them by the muscles after recovery from anæsthesia, that the process of capillary budding ceases or becomes inadequate for the needs of connective tissue union and ossification. As Kellogg Speed puts it, "the vascular outgrowth is disrupted, disheartened, and ended." Robinson (11) discusses the danger of movement of the fragments and its effect on granulation tissue. He shows how opposed to the physiological principles of union Lucas-Championnière's teachings were in this regard.

4. Similar disorganization may be produced by rough manipulation after the formation of soft callus. While nature may be expected to persist in spite of her first efforts having been undone, it is probable that, in cases unfavorable for other reasons, the effort will not be repeated. When such trauma results in the rupture of vascular continuity between intact bone and a large mass of granulation tissue or soft callus, these become actual obstacles to union until vascular continuity with them can be re-established. In essence, a comminuted fracture now exists. If the fragment of new tissue is displaced, it may constitute an insurmountable obstacle.

5. Since blood may be brought to the area of fracture by periosteum (from the muscles), by the nutrient artery, through the marrow, and by the haversian system, it is not likely that all sources will fail. If the laceration of muscles is so great that the periosteal circulation is diminished, or if the nutrient artery is ruptured, or if the pressure of excessive hæmatoma or congested soft tissue on the area of fracture is so great as to impede the circulation to it, any one of the other causes may be sufficient to defeat the efforts at union.

6. Infection is a cause of non-union the influence of which has, in some respects, been much discussed. Local acute inflammation of certain types is a stimulus to the formation of granulation tissue and even of callus. One has observed the stimulation of union following erysipelas about a compound fracture. Still, the destructive effect of infection on callus and formed bone is not to be disputed. When inflammation results in extensive thrombosis, necrosis must ensue in bone as in any other tissue.

A destructive type of low grade infection is often associated with the presence of foreign bodies in the fracture zone. It is a common experience to find pus about metal plates and extending between the fracture surfaces. In such cases, if granulation tissue has been thrown out by the bone elements, it has been destroyed and no evidence of beginning union is evident.

7. Lane's plates, especially when incorrectly applied, may cause non-union. At best, the necessary stripping of the soft parts leaves the ends of the fragments isolated and impairs the circulation especially to the periosteum. The ends of the fragments are thus robbed of nourishment and may even be devitalized. If the bone ends are distracted, the stimulation of mutual opposition and fracture surface stress is lost; moreover, the greater the distraction, the wider the space to be filled with granulation tissue and the greater the danger of the connective tissue contracting to form avascular scar tissue before ossification is complete. The proneness of low grade infection to set in, in the presence of foreign bodies, has been referred to. In a surprising number of cases, when removing metal plates in non-union, I have observed a thin, seropurulent fluid (due to the foreign body irritation) between the fragments, and I have considered such exudate a serious

obstacle to the formation of granulations and to ossification.

8. A rarer cause of non-union is absorption of solid callus before restoration of trabecular alignment has been completed. Manual examination of the site of fracture, even the X-ray study of it, may reveal no occasion for caution. If more function and stress are permitted than the new bone can accommodate itself to, the new structure may be absorbed. Since this accommodation consists of the absorption and reconstruction of trabeculæ and rearrangement of the vessels of the haversian system through the callus, and since these depend upon the abundance of blood supply, it is clear that, if vascularization is restricted or circulation impeded, absorption of callus is more likely to occur when function and stress are permitted. It is one of the purposes of massage to ensure circulation proportionate to the demands of the stress of early function.

The reparative response after fracture seems strikingly independent of systemic conditions. It does not vary directly with the general state of health, nor is it affected, with any constancy, by diseases characterized by malnutrition or general debility. There is a general feeling that old age must cause inhibition of bone growth. This is not clinically a fact. Bones of aged people seem to unite with the same facility as they do in the young. By all odds the most stubborn non-unions are in the infant or young child, particularly if the fracture was intra-uterine. Some surgeons of considerable experience have gone so far as to recommend amputation in all cases of intra-uterine fracture. My statistics show that in such cases, by instituting operative treatment in conformity with the physiological and biological principles of bone repair, I have succeeded in inducing union in about 60 per cent.

CASE 1. This child was 9 years old when I first saw her. The diagnosis was congenital pseudarthrosis of the left tibia and fibula. At the age of 3 or 4 years a graft taken from the father's leg had been applied, but the child fell off a chair and broke it. A second graft from the father's leg was tried when she was 5. The complete failure of these attempts is shown in Figure 1 A.

I used an inlay graft from the patient's sound tibia. The result 2 months later is shown in Figure 1 B. I tried having the child walk with a brace, but 5 months later it was clear that union would not occur. I operated again, using an inlay graft and two sliver grafts from the other tibia. Five months later union was solid (Fig. 1 C and D), and the child was walking with a brace. At the latest report, nearly a year after the operation, the leg was still firm.

In this case a homogenous graft had been used twice. This should never be done unless an autogenous graft is not available. In the latter case the donor and recipient should be of the same blood-type.

CASE 2. This was a case of intra-uterine fracture of the left tibia and bowing of the fibula. Various operations had been performed but union was never permanent. Wiring and bone grafting had been tried, both separately and in combination. Figure 2 A and B illustrate two of these attempts when the child was 3 years old. I saw the child when she was 6; the non-union and bowing are shown in Figure 2 C. I used a double-wedge-end inlay graft taken from the child's other tibia. I also performed osteotomy to straighten the fibula. Figure 2 D and E (taken a month apart) show the result 2 years later. Four years after this operation, the child was reported to be as active as the normal child, and it was considered that functional restoration was complete.

Five years after the operation, the child slipped and the tibia fractured in its lower third. Reunion was effected by the use of a plaster splint, but refracture occurred 3 months later. Plaster splinting again brought about union. The condition 7 years after the operation is illustrated in Figure 2 F. Now, 14 years after operation, the function of the limb is excellent and union is solid.

This was Dr. Clarence William's case. He performed the early operations but finally became discouraged and kindly referred the case to me. The case illustrates how necessary it is for the surgeon to be able to apply immobilizing splints and apparatus, not only immediately after operation, but during convalescence.

The causes of non-union may be grouped into those concerned with the formation of granulation tissue and those concerned with the ossification of that tissue. Bancroft makes so little of the second group of causes that he states: "If a fracture is immediately treated in a manner which will replace as far as is feasible the fractured ends in suitable opposition and allow for organization of the clot and ingrowth of granulation tissue with its accompanying vessels, repair will inevitably follow." Clinical experience in cases of multiple fracture supports Bancroft's belief that the causes of failure of union are local; one fracture may

unite and another fail. Still, I would not make so sweeping an assertion as Bancroft's. It is true that investigation of one systemic disturbance, that of the calcium and phosphorus content of the blood, has been inconclusive; but since, as I have pointed out, nonunion may be the result of failure of the preliminary stages of healing and may thus have no connection with ossification, conclusions from observations of a mixed group are of necessity contradictory and erroneous.

The end-result in non-union varies with the fate of the granulation tissue. If it has formed a complete bridge but has degenerated into fibrous tissue there may be a dense mass of scar tissue between the fragments, constituting fibrous union. If it has been largely destroyed by pressure and movement of the fragments, the space it occupied may be filled with a pseudo-synovial fluid enclosed in a capsule which represents the peripheral portion of the original granulation tissue. This is the pseudarthrosis. In other cases there is no evidence that granulation tissue ever bridged the gap, the fragments being entirely displaced and disconnected.

GENERAL PRINCIPLES OF TREATMENT

Non-operative measures. In a general way, it is to be expected that measures directed to the improvement of general health will aid bones to unite. The relationship of general health and vigor to the process of union has already been discussed. We do not know what forms of organic food are most beneficial, but we assume that foods containing more calcium and phosphorus are to be prescribed, although there is in the bones an ample reserve of these substances awaiting mobilization by the mechanism that normally governs calcium metabolism. There is nothing specific, therefore, in the dietary treatment in fracture cases. The direct administration of calcium and phosphorus I consider unwarranted scientifically, and probably useless.

The same may be said for ultraviolet light and irradiated sterols. Certainly ultraviolet light can have no direct local effect, since the ray can penetrate such a slight distance. It has been suggested that calcium and phosphorus are ionized in superficial tissues, and that electrical modifications in the proteins of the skin cause changes in the hydrogen-ion concentration. The most likely explanation of the value of ultraviolet in the treatment of rickets and malnutrition is that the energy is absorbed either by cholesterol or by fluorescing materials in the skin and carried by them to regions where the energy can be used to induce chemical change. The effect of these methods in the treatment of rickets is no criterion of their value in ununited fracture; there is no proof, or even indication, of resemblance between the two conditions. Nor does the fact that lack of ultraviolet light (and of vitamine D) leads to failure of calcification furnish proof that failure of union is due to such deficiency, or that administration of them in excess will promote union or even calcification. Bancroft's opinion of the requirements for union, already quoted, and the growing belief that the causes of non-union are local shake one's confidence in all general measures. Kellogg Speed apparently agrees with Bancroft's statement, yet he recommends general measures in considerable variety: the ultraviolet ray if the patient is septic, a high protein diet, vegetables, and milk. There is only the vaguest reason why ultraviolet should counteract sepsis; the high protein diet is presumably based on Clark's demonstration of increased rate of healing of wounds in a dog when the diet was entirely protein.

Even if it is granted that a high protein diet will accelerate the formation of granulation tissue, one must consider the possible effect of diet on calcium metabolism. A potential acid diet may increase the elimination of calcium to a marked extent, and it is probably of greater importance that the diet be neutral or of low potential acidity. If it is not, then food rich in calcium should be added. The question of diet is still in the hands of the physiologists. The most unlikely remedy is parathyroid extract, which has been injected because it increases the calcium content of the blood, even though this is at the expense of the calcium in the bones. There is nothing in medicine that more aptly illustrates the danger of a little knowledge. Speed is not by any means alone in prescrib-

ing phosphorus, although its only known effect on bones is to cause their necrosis. The effect of large doses is no proof of the effect of a small one, but the contrast illustrates how much speculation there is behind all of these general measures. Although it would be unwise to discourage attempts to put new discoveries to the therapeutic test, one must admit that, in many of our efforts, we have strained if not violated these principles and have leaped without our eyes clearly open. I do not believe that, at the present time, one can recommend any specific medication or dietetic treatment.

In cases of delayed union, it is often desirable to use the limb, carefully protected by braces against lateral stress. The pressure of the fracture surfaces on each other will stimulate osteogenesis if there is any source of granulations and of osteogenetic cells in the vicinity. In well established non-union and in frank pseudarthrosis, the fracture surface is quite incapable of making any response of either kind.

Speed discusses Bier's hyperæmia and Thomas' pounding method and tries to establish some physiological justification for them. Nobody has ever explained why congestion with sluggish circulation, induced by trauma or otherwise, should supply more nutrition or calcium salts than free normal circulation. Stasis must depress local metabolism; and there is no agreement on the effect produced by an increase in the hydrogen-ion concentration of the blood in stasis. Robison's phenomena occur at a low hydrogen-ion concentration. These chemical reactions must not be detached from their physiological background; one must remember that ossification takes place in a specialized tissue the existence and physiological activity of which constitute the first requisite of callus formation and bony union.

The pounding method of Thomas is not to be explained on a chemical basis and not to be justified on any basis. It is at best a crude and blind method of freshening tissues at the site of non-union; it may result in the formation of fresh granulations which may carry a bony bridge from fragment to fragment.

A B C D

Fig. 1. Use of the bone graft in a case of intra-uterine fracture of the tibia and fibula (Case 1). A shows the failure of a homogenous bone graft. B illustrates the result of author's first attempt with an autogenous graft inlaid into the tibia. C and D are two views 5 months after the insertion of a second autogenous graft which was successful in promoting complete union.

Operative measures. There is only one way to treat non-union and that is by open operation. The site of fracture must be carefully exposed so that the conditions inhibiting union may be recognized and suitably dealt with. As time has gone on, the importance of vascularization has been so much impressed on me that I have entirely changed my attitude to the ischæmic scar between and around the ends of the fragments. I now remove not only all such, but scar in the neighboring soft tissues as well, so that circulation may be restored and the fragments revitalized. Non-union is a most stubborn condition because it is a fixed end-result which nature has accepted in lieu of the normal; the stimulus of incompleteness has ceased to act. The operative measures instituted should be those which the surgeon believes will be most likely to result in union. It should go without saying that, in accordance with surgical principles, he will not be satisfied with anything short of his best effort. In no other branch of surgery, so far as I am aware, has any attempt been made by a responsible surgeon to justify methods which can admittedly succeed only occasionally, and to condemn other methods

Fig. 2. Case of intra-uterine fracture of tibia and fibula (Case 2). A and B show the results of bone grafting and wiring. C shows the condition at the time of first observation. D and E were taken 2 years after the insertion of a double-wedge-end graft and osteotomy of the fibula by the author. F shows the ultimate result 7 years after traumatic fracture and subsequent union brought about by splinting.

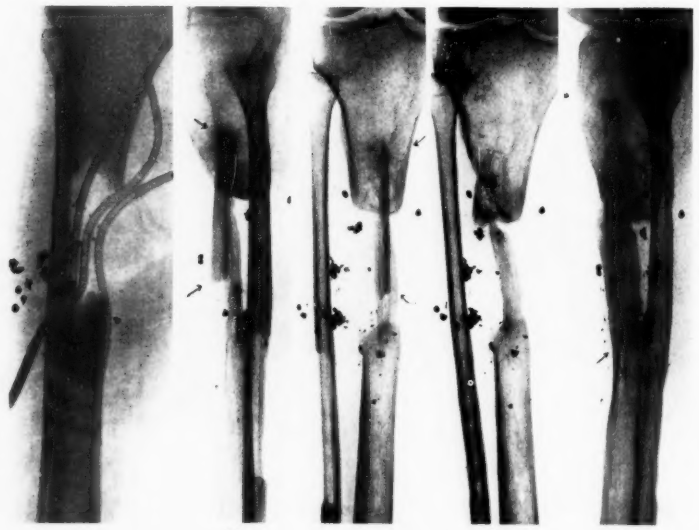


Fig. 3. Progress of a case of gunshot wound with infection and loss of substance of the tibia (Case 3). A shows the original infected wound. B, C, and D, ineffective attempts at bone grafting, with material taken from the fibula and elsewhere. The flimsiness of the fibular graft is evident in C. E shows the result 7 months after the author's insertion of an inlay graft from the sound tibia. It is now a year since the operation and the leg is functioning normally.

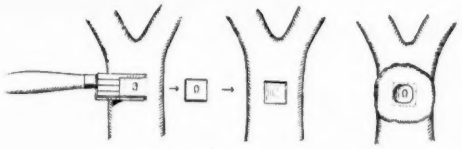


Fig. 4.

Fig. 4. Method of removing graft consisting of bud with portion of bark and alburnum and fixing it in a gutter in the host. The double-bladed knife, like the twin motor-saw, ensures accuracy of fit. The paraffin dressing provides immobilization and access to light.

Fig. 5. Method of preparing graft bed and inserting graft. The longitudinal section shows the graft in place, each element making close and intimate contact with a similar layer in the host. The nutrition of the graft, diagrammatically represented, comes from the marrow and periosteum of the host. (The linking up of the two vascular systems by means of granulation tissue cannot be represented because of the microscopic size of the granulation area between host and graft.) The cross sections, one through healthy bone and the other through sclerotic bone, show the difference in vascularization at these two levels. The right and wrong ways of using the twin-saw are represented below.

on the ground that "reasonable" exactness will usually suffice. If a surgeon were satisfied that the method of drilling the fragments

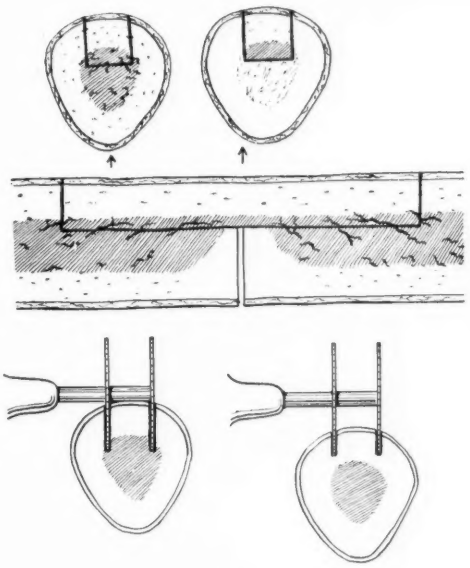


Fig. 5.

A B C D E

Fig. 6. Use of a sliding graft for non-union of tibia (Case 4). Non-union of both tibia and fibula with displacement is shown in A. The sliding graft ultimately used is seen in B and C. The result 3 months after the operation is shown in D and E. Note the filling in of the cavity left by removal of the sliding graft. Some concomitant of the operation, possibly the immobilization of the tibia, would appear to have stimulated osteogenesis in the fibula.

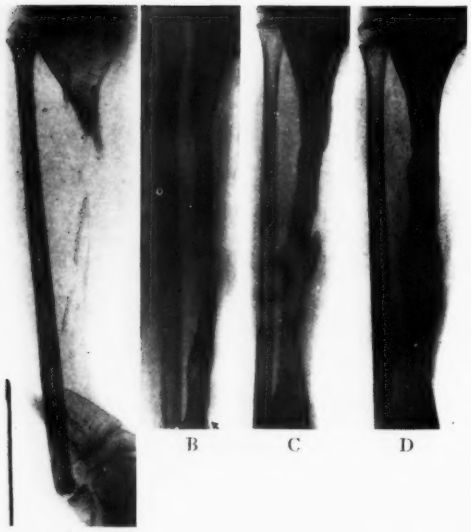


Fig. 7. Use of a long inlay graft following marked destruction by osteomyelitis (Case 5). The 6 inch gap in the tibia is seen in A. The inlay in illustrated in B, taken 4 months after the operation. Subsequent fracture of the graft, seen in C, united when the limb was supported with a brace. Not only re-union of the graft but marked enlargement of it are evident in D.

blindly through a small incision was the ut-
most that could be done for the patient, I
should have no criticism to make; it is the
advocacy of nibbling tactics that one finds so
disturbing and so subversive of sound surgery.
In the series which I shall presently review
prior operations, much more commensurate
to the needs of the case than this one, had
been performed in 42 per cent, with failure
and often repeated failure, in all.

To show the inconsistency between clear
appreciation of surgical principles and the
way these principles are applied to practice, I
quote two passages from an article in one of
our best surgical journals; "Even slight too
early motion after a well planned and executed
operative treatment may militate against a
successful result"; and "Too rigid, too ex-
tensive or exaggerated methods of internal
splints are not often required." How can

Fig. 8, left. Inlay graft in a case of gunshot wound with loss of substance (Case 6). The non-union, with little sign of callus, is seen in A. The result 4 months after the operation is illustrated in B. Callus can be seen about the graft.

Fig. 9. Case illustrating operative treatment of fractured graft (Case 7). Osteomyelitis had resulted in considerable loss of substance with a hiatus between the fragments, A. The result 4 and 8 months after the insertion of an inlay graft is seen in B and C. The wedge ends of the graft can still be seen in B. Fracture of the graft 2 years later is evident in D. Treatment by means of sliding graft taken from original inlay and result are illustrated in E.

xation be too rigid? Certainly for those of s not endowed with sufficient vision to select he cases in which slip-shod methods will uffice, there is only one course: we must use he most exact technique and the most precise nethods that the unfavorable case would lemand.

In the treatment of non-union, surgeons dopt methods varying from the purely me-hanical to those which are based on the most ccurate conception of the process of union which physiology and biology can supply. In between the two come various methods which violate one or more of these fundamental principles: one sacrifices immobilization; another takes no account of the necessity for optimal vascularization; according to another, boiled bone is a graft or differs in virtues and drawbacks from other inanimate foreign material.

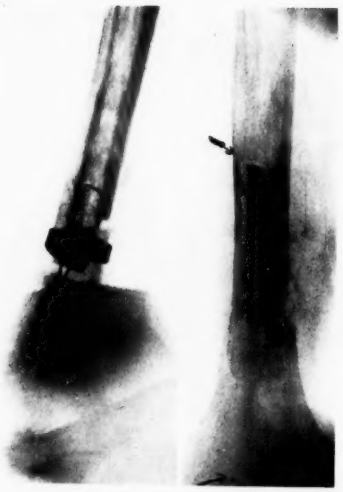
Fig. 10. Metallic relics of four different operations which had the mechanical aim of promoting union and the physiological result of preventing it.

The surgeon who is the greatest menace to progress is he who, while admitting the unsoundness of his methods, persists in them because his results, although not satisfactory, are better than he can obtain with a technique that is physiologically superior. General sur-

Fig. 11. Failure of intramedullary graft and success of an inlay in the tibia (Case 8). The failure of union after non-operative treatment is illustrated in A. The intramedullary graft is seen in B which shows also the extensive reaming out of the marrow and the destruction of it produced by manipulation of the graft in making it engage both fragments. Note shortness of graft indicated by arrows. The author's inlay is shown 2 months after the operation (C and D) and 1 year after (E and F).

A B

Fig. 12. Failure of onlay graft following failure of an intramedullary graft (Case 9). The defective immobilization and uncertain contact of the intramedullary graft are clearly exemplified in A. Apparent success of the onlay, applied by the author, is seen in B. It eventually fractured and loosened and was replaced by an inlay.



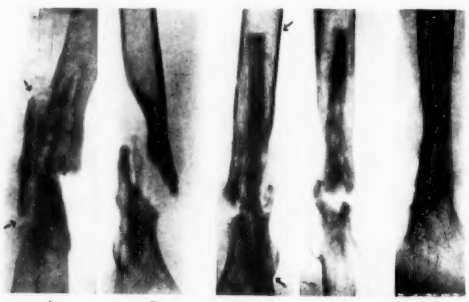
A B

Fig. 13. Failure of the Senn operation followed by successful application of the inlay graft in the humerus (Case 10). The net result of two previous operations is suggested in A. The metal remains and union has failed, but there is only a general indication of the shortening actually produced by intent and injudicious application of metal. Proliferation of the inlay graft is evident in B.

A B C D

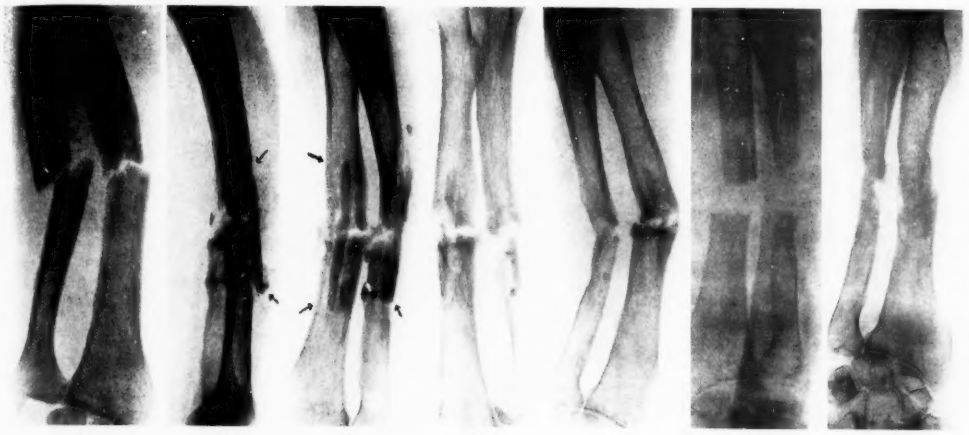
Fig. 14. Incorrect and correct methods of inserting a graft into a smaller long bone (Case 11). The almost inevitable disaster awaiting the attempt to put an intramedullary graft into the radius is illustrated in A, which shows fracture of one host fragment, and in B, which shows the later absorption of the radial fragment and of the graft. The successful application of the double-wedge-end graft is illustrated in C. D shows the thorough amalgamation of the graft 2 months later.

gery has passed this stage; its progress has gone on hand in hand with progress in physiology and biology. It has sometimes gone in advance of physiology and demonstrated phenomena that the physiologists must explain; but it has never gone counter to well established scientific principles. The



A B C D E

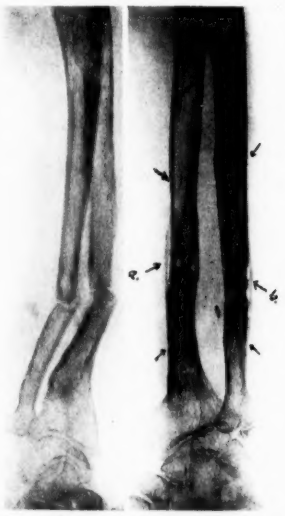
Fig. 15. Destruction of graft into humerus by recrudescence of infection; inlay of second graft in original inlay (Case 13). The attempt at grafting and the condition at the time of first observation are shown in A and B. The author's first inlay, C, was destroyed at its central portion by infection, D. The second and successful inlay, into the remnants of the first, is shown in E.



A B C D E F G

Fig. 16. Successful use of the double-wedge-end inlay graft after the failure of many operations (Case 14). The early condition is shown in A. Failure of bone grafts is seen in B, C, and D, taken over a period of 8 months. The roentgenogram in E was taken 10 days after a later suturing operation following extensive removal of bone. The result 6 months after the double-wedge-end inlay operation by the author is illustrated in F.

treatment of goiter is applied physiology; postoperative tetany was clearly explained by the physiologists. Intrathoracic operations have been made possible only by the elucidation and better understanding of the physics and physiology of respiration.



A B

Fig. 17. Successful use of double-wedge-end inlay grafts in non-union of the radius and ulna (Case 15). The original non-union is seen in A; the roentgenogram in B was taken 3 months after the insertion of the double-wedge-end inlays. The arrows at *a* and *b* indicate the sliver grafts; the others point to the ends of the inlays.

A B C

Fig. 18. Prompt union following the use of double-wedge-end inlays in a case of non-union of radius and ulna at the age of 63 (Case 16). The non-union is shown in A; the result at intervals after the operation is illustrated in roentgenograms B and C.

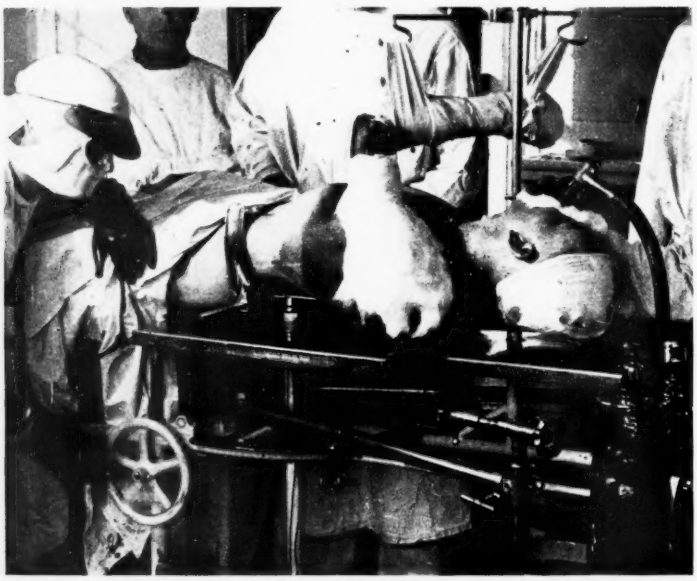


Fig. 19. The author's fracture orthopedic table with patient in position for a shoulder spica. Both trunk and arm are held in correct position by adjustable attachments until the plaster has been applied and molded and has set in position.

So one might review the whole field of general surgery. One can only hope that, in the field of bone surgery, the same determination to rely on fundamental principles will be manifested. If a surgeon can obtain respectable results with inaccurate methods, it stands to reason he should do better with scientific methods. If he does not, then either the scientific principles need to be re-examined or he is incapable, with his training or his armamentarium, of applying those principles accurately. It should be clear to all of us which way progress lies.

Fig. 20. Spica of shoulder extending to the hand, completed.

CASE 3. The patient was 29 years old. Non-union of the tibia was the result of loss of bone substance following gunshot wound 5 years before. Two attempts had been made by other surgeons to bridge the gap by bone grafts, once by a sliding graft and once by a graft from the fibula. The original infected wound with loss of substance is illustrated in Figure 3 A. The fate of the grafts is shown in B, C, and D.

I used an inlay graft from the other tibia. The result was excellent. The roentgenogram shown in Figure 3 E was taken 7 months after the operation. It is now a year since the operation and there have been no complaints.

The failure of the original grafts and the success of my own attempt can be explained only by difference in technique. Either the original surgeon did not possess machine-driven instruments or he was not sufficiently experienced and adept in their use

Failure following fibular graft may have been due to thinness or weakness of the fibular cortex. Rib grafts are still weaker and should not be used where they will be subjected to strain as they must be in the treatment of pseudarthrosis.

When to operate after infection. If there is a history of infection one should wait 2 months from the time the skin healed. In the case of such a persistent infection as that with streptococcus hæmolyticus, it is necessary to wait longer. Experience has taught that, in general, a longer wait than 2 to 4 months does not increase the safeguard against recrudescence.

PRINCIPLES OF TREATMENT BY BONE GRAFTING

The principles of grafting are exemplified in their simplest form in plant grafting. One can safely assume that the principles of plant grafting cannot be violated in the grafting of tissues of a higher form; and that grafting of bone cannot be as readily carried out as grafting of vegetable material. These postulates arise from the very nature of biological principles and the decrease in adaptability with increase in specialization of tissue. There are three inviolable rules in plant grafting: the tissues must be applied like to like, the contact must be most intimate, and they must be immobilized in that position. These are at least as important in bone grafting. In the more highly specialized animal tissue, however, it is desirable, if not essential, that the graft be autogenous.

When the bark and bud are removed for the scion, a piece of bark of the same size and shape is removed from the host (Fig. 4), so that like tissues of the scion will be applied to like tissues of the host and so that immobilization will be facilitated. Interruption of the circulation of sap in the host is thus minimized. The "taking" of the graft consists of the laying down of new cells, partly by the host and partly by the scion, which eventually fuse.

It is thus evident that the cells of the scion preserve their vegetative and proliferative power. The re-establishment of the circulation is simpler in the plant, but it is obvious that the sap must permeate the cells of the scion or the latter will eventually die. In

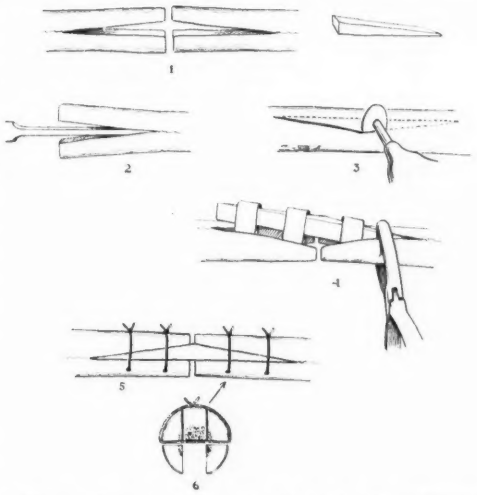


Fig. 21. Steps in the insertion of the double-wedge-end inlay. The wedge-shaped recess in each fragment and one of the wedges removed are shown, 1. The osteotome is being used to split the fragment beyond the recess when an oversize graft is necessary in smaller bones, 2. Removal of the graft from the tibia, 3. The U-shaped tin skids shown are used to facilitate the insertion of an oversize graft, the forceps causing the skids to separate and "spring" the bone as the graft is forced into position, 4. The position of the suture holes and final position of the suture are also shown, 5 and 6.

bone, re-establishment of circulation becomes a problem the solution of which governs the whole question of surgical technique.

Of all the layers in a tree-bark, alburnum, heart-wood, and heart—the alburnum is the important one in grafting, since it is the proliferation of its cells in scion and host that brings about the union. In bone, and especially in long bones, the structure is much more complex and all the layers, periosteum, cortex, endosteum, and marrow, take part, to a greater or less extent, in union.

Immobilization is effected in plant grafting in two ways, in addition to the fixation provided by the accurate fit of the scion: the site of grafting is either bound with many layers of fabric or is covered with wax or, better, paraffin (Fig. 4). These sealing substances serve as a sterile dressing as well, since they keep out fungi. If paraffin is used, immobilization is just as secure, and light (especially the ultraviolet) is allowed to penetrate to the wounded tissues and especially to the bud

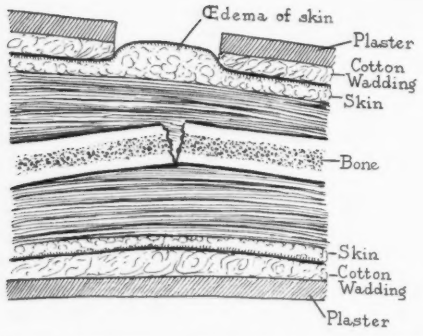


Fig. 22. Diagrammatic longitudinal section of a limb in plaster with a window, to show the displacement of the fracture fragments produced by the unequalized pressure and the protrusion (and consequent œdema) of the soft parts through the opening.

which needs the ultraviolet for the metabolic activity of its chlorophyl.

Plant grafting and bone grafting thus have the same objective and are carried out according to the same fundamental principles. The application of these in bone must be more meticulous since there are added difficulties in a relatively highly specialized tissue nourished by a system of closed vessels.

In the plant, the only force to be counteracted is that of the wind, and this only when the scion is a large shoot. In bones there is the pull of muscles, both tonic and voluntary, and the exaggeration of the former by reflex from pain. Fixation and immobilization, therefore, present difficulties which must be met in a special way.

Bancroft's statement in regard to union of fresh fracture is even more applicable to the union of the bone graft: "The most important factor for the union of fracture is to have the fractured ends in close opposition and to have an adequate blood supply to allow the ingrowth of granulation tissue with the resultant ossification to form callus." Adequate blood supply and coaptation are even more necessary in the case of the graft, because the stimulus which recent fracture gives to osteogenesis is lacking in the old fragments. In the fresh fracture, there is usually an adequate blood supply in marked contrast to the ischæmic state of a pseudarthrosis. Union of the graft, therefore, proceeds under difficulties that must be counterbalanced by the most careful methods in its application.

Vascularization of the graft. Just as the union of fracture fragments is fundamentally similar to that of severed soft tissues, so the union of bone grafts with the host is similar to that of fascial or tendon grafts. It has not been shown that in either of the latter the graft is replaced by overgrowth of local tissue. Garlock investigated the stages of union and the fate of a tendon graft: "The experiments reported in this paper show definitely that the graft lives as such." His description of the nutrition of a tendon graft may, with suitable changes, be applied to that of a bone graft: "It is probable that the graft derives considerable nutrition from the tissue juices . . . . It is probable that the main source of nutrition is from the outgrowth of young capillaries and lymph vessels from the tendon ends and from the subendothelial tissues of the sheath."

The various layers of a bone graft freshly removed present raw surfaces wherever they have been cut. The vessels are severed but still contain blood which tends to clot at the point of section. The various tissues of the graft are capable of survival for a considerable time, but it is of the first importance to restore its blood supply and nutrition. The graft must be placed in the most favorable environment for this end (Fig. 5). If it is so placed that the elements of the graft (periosteum, cortex, endosteum, and marrow) make direct and intimate contact with similar elements in the host, the soft tissues of the bone first unite across the slight gap, vascular continuity of host and graft is re-established through periosteum, endosteum, and marrow, and a granulation-tissue bridge is laid down between the bony surfaces. Osteoblasts appear in the granulation tissue and determine the deposition of lime salts. If the process follows Bancroft's picture of healing bone, the continuity of the haversian systems will be indirect until the normal architecture has been established between the graft and the host. Under ideal conditions, the greatest possible number of capillaries of host and graft are brought into the closest mutual approximation. The graft will then remain intact. If such conditions are not provided, smaller or

larger areas of the graft will fail to be nourished and will ultimately be replaced. The process by which the bony structure of the graft is later rearranged to conform to the structure of the host is in no sense absorption. The process can be called assimilation, if the term is used in the sense that the graft assimilates itself to the host. The graft is not the subject of processes imposed upon it by the host; it is itself the active agent in its own rearrangement under the influence of the stresses which it encounters in its new environment; it has the power of adaptation.

If all the elements of the graft cannot be brought into contact with similar elements of the host, the marrow at least should be. Johnson's conclusion that the circulation was re-established, 75 per cent by the marrow and 25 per cent by the periosteum, indicates the share which each tissue has in osteogenesis.

That the blood supply is the key to the situation is shown by certain clinical observations. When a large anæmic scar surrounds the region of non-union, it is admittedly good practice to replace the scar with a pedicled skin graft laid right on the ununited fragments. Union occasionally follows such preliminary treatment. In any event, the chances of union are much enhanced by the methods which improve the circulation to the tissues adjoining the non-union and through them to the periosteum of the fragments and of the graft, if one is inserted. Correspondingly, the chances are diminished by interference with the circulation to the graft. The original fracture may have been accompanied by laceration of tissues, such as tendons and nerves, which still demands repair. The operations should be taken in order of their urgency, and the success of the bone graft should not be jeopardized by another operation performed at the same sitting. Extensive dissection not only necessitates prolonged exposure of the wound to the air but interferes with the circulation to the soft parts. Many of the smaller blood vessels are severed or occluded as the result of the trauma. Tissues in this state constitute a very unfavorable environment for the bone graft.

CASE 4. In this case, both tibia and fibula had been fractured, at the junction of middle and lower thirds, 3 months before I saw the patient. A cast, followed by a brace, had proved ineffective, and non-union was evident (Fig. 6 A).

Believing that lack of osteogenesis had not been shown, I brought the fragments into apposition, mortised them, and sutured them with kangaroo tendon. The failure of union, evident on removal of the cast 2 months later, indicated that osteogenesis was not vigorous; and the failure of massage and the use of a brace to promote union confirmed this conclusion. Accordingly, 6 months after the first operation, I made use of a sliding graft. In Figure 6 B and C show the result 2 months later and D and E at the end of the third month. Union by this time was solid and the result is still excellent 9 months after the operation.

This case illustrates the point that the fibula is usually ignored in fracture of the lower leg. I have never put a graft into the fibula. It was quite clear that the fibula was out of place, but the questionable advantage of repairing it was quite outweighed by the disadvantage of interfering with the circulation in the vicinity of the tibial graft. Nothing should be allowed to prejudice the success of the main effort, which in this case was repair of the tibia. For this reason I have never attempted to develop nerve ends or to repair lesions of nerves in the zone of fracture. Such operations should be undertaken either some time before the graft is inserted or long enough after it for the trauma and vascular disorganization to have no prejudicial effect on the vascularization and union of the graft.

When the fragments of a non-union are osteoporotic, the chances of union, instead of being diminished, are actually increased. Osteoporosis is associated with increased vascularity; and this must account for the rapidity of union of a bone graft in such cases. True, a sliding graft (from one of the fragments) may be so flexible as to afford poor immobilization, and an autogenous graft from some other region may be little firmer; but the graft will unite readily because of the abundant blood supply.

Relation of coaptation to union. The approximation of graft to host is analogous to closure of a wound in soft tissue. If the opposing surfaces are poorly approximated, much granulation tissue is required to fill the gap, and healing is slow. If the surfaces are brought into close contact, the layer of granulation tissue is of microscopic thickness and healing by first intention results. This speedy granulation tissue union not only re-establishes the circulation in the graft at the earliest moment, but results in the deposition of the

thinnest possible layer of callus between the bones. This necessitates the least possible rearrangement of the callus trabeculæ. It is thus evident that not only the viability of the graft but the promptness and durability of union and the rapidity of assimilation of the graft to the host tissues depend on close approximation of graft to both host bones. In non-union, the surgeon will find that nature has little callus for him and he must make the most of the meager supply; he must draw on mechanical principles to compensate for the meagerness of the physiological reaction.

When a graft containing all four elements is placed in intimate contact with the same elements in the host, it acts as a vascular and osteogenetic unit; vascular union proceeds along the lines of natural repair and a bridge is placed between the two fragments which calls for the minimal amount of trabecular and vascular readjustment to take on the function of the host bone it replaces. If the graft is inserted or attached in any other way, vascular communications are limited (and the viability of the graft thus jeopardized) and the graft may have to be largely or entirely reconstructed by nature before it assumes the structure suitable to the stresses exerted on it. It is under such circumstances that absorption occurs.

Relation of immobilization to union. When soft tissues are uniting, their flexibility minimizes the danger of disruption of the granulations. When such rigid tissue as bone is uniting, the least displacement may tear the granulations and blood vessels or fracture the soft callus. Hence the necessity for the most accurate and stable immobilization. From the mechanical standpoint, the advantage of "internal" immobilization needs no proving. Here again the inlay graft is superior: it exemplifies the mechanical principle of the slot and key.

When the healing fragments and the graft are thus held in rigid immobility, the granulations and callus are protected not only between graft and host but between the two host fragments. The stress of maintaining immobility falls on the graft and, under this influence, the graft grows in size and strength (in accordance with Wolff's law) and adapts its structure to the stress. A graft the size of a pencil, when inserted into the femur, will grow to the dimensions of the host bone and assume an identical structure, by its power of adaptation.

To illustrate the ability of a graft to replace lost bone, even up to the major portion of the shaft, I present 3 cases in which, either because of old osteomyelitis or gunshot wound, there was extensive loss of substance. These may not come strictly within the scope of the paper, but it is hoped that consideration of them (particularly Case 5) will dispel the notion that there is any place in practical surgery for the conception that the bone graft is a mere scaffold of transient value and doomed to absorption.

CASE 5. The patient was a girl 8 years old. Two years before, osteomyelitis had necessitated the removal of 6 inches of bone from the left tibia. The condition when I saw her is illustrated in Figure 7 A.

The appearance of the graft, 4 months after the inlay operation, is shown in Figure 7 B. A few months later the graft fractured as is shown in C. The patient was given a brace and the graft reunited without trouble. The roentgenogram (Fig. 7 D) shows not only solid union but marked growth of bone in the graft. It is now more than 8 years since the operation and the graft has given no further trouble.

In this case a great deal of bone had been lost and was successfully replaced by a tibial graft. The limit to the length of the graft is determined only by the length of the bone it is taken from. The case also demonstrates the probability that the fractured graft will reunite if adequate immobilization is provided. If, as occasionally happens, it does not reunite even then, a graft may be placed in the original graft as is illustrated in Cases 7 and 13.

CASE 6. This case illustrates the use of the bone graft for loss of substance following gunshot wound in an adult. The accident had occurred during a hunting expedition. There was much laceration of tissues and troublesome hæmorrhage. Infection and sequestration occurred during the early course. The former was controlled by the Carrel-Dakin treatment and the wound healed after 9 months. Considerable bone had been lost and many shots were scattered through the soft tissues when I first saw the patient. Non-union was present and there was little evidence of callus formation (Fig. 8 A). No attempt at surgical repair had been made and no fixation had been provided except by splinting.

I bridged the gap with an inlay bone graft from the patient's tibia. Figure 8 B shows the result 4 months later. Callus formation is evident about the graft. It is now 8 months since the operation and the graft is still solid.

I made no attempt to remove the shot. Foreign bodies with no infection about them can be left; it is a mistake to attempt the impossible. Nothing may be gained and much may be lost by interfering needlessly with the circulation when a graft is inserted (see discussion of Case 4).

CASE 7. In this boy of 12 years, loss of substance had followed osteomyelitis of the left tibia 2 years before. After operation and prolonged drainage, the wound had healed in 6 months leaving a gap of 2 inches in the tibia (Fig. 9 A).

I used an inlay graft from the sound tibia. The result 8 months later is illustrated in Figure 9 B. About 2 years later the patient broke the graft (Fig. 9 C). (This roentgenogram was taken a few weeks afterward.) About 2 months after the fracture, I used a sliding graft from the original graft, with an excellent result (Fig. 9 D). Five years after the last operation the result is still splendid.

In this case the sliding graft for the second operation was entirely supplied by the original graft. Nothing could better prove the vitality of the original graft more than 2 years after it had been inserted. Fracture of the graft is not the common result; these cases are presented to show that it will unite again and that it has vitality and osteogenetic power.

Necessity for power driven tools. The entire process of union and the survival of the graft depend on the establishment of vascular connections between the graft and the host fragments; the rapidity of establishment and the degree and permanence of vascularization vary directly with closeness of coaptation and rigidity of immobilization; these depend on accuracy of fit. The necessity for the greatest precision in the mechanical procedures needs no further argument; ideal conditions can be produced in no other way than by the use of automatic, power driven tools which can be adjusted to cut with mathematical exactness both the graft bed and the graft which is to fill it.

Fortunately, all bones are filled with cancellous tissue or marrow and are thus well suited to the inlay technique. The universally adjustable twin saw which I designed 20 years ago serves ideally, as similar tools have served similar purposes in the industrial world.

Relationship of mechanical, physiological, and biological principles. The most unfortunate and the most general misconception of the treatment of non-union is that it is a mechanical problem. The idea is inherited from the principles of the treatment of fresh fracture. The traditional methods are based entirely on mechanics: how to overcome distorting forces and how to maintain alignment by the application of counter forces or stress. If, after reasonable reduction and immobilization of the fragments, union fails, the problem passes from the realm of mechanics into those of physiology and biology. It is not to be expected that repetition of mechanical methods will be successful, since the stimulus to granulation and ossification has abated. Even in the open treatment of non-union this faulty conception is evident. Methods are commonly practiced which have no other basis; and there are surgeons who apparently believe that two pieces of bone must unite if held together and that the method of approximation and means of maintaining it have no bearing on the success of the operation, other than through mechanical fixation.

In one case that came under my observation, the surgeon had begun by plating the fragments. When failure by this method was evident in due course, he used wire; after another disappointment, he resorted to nails. The third failure did not by any means shake his confidence in purely mechanical means; with a persistence worthy of a better cause, he put all three back—plates, wire, and nails (Fig. 10). Four times did he try to find a mechanical antidote for the particular case. He did not fail for lack of skill; applied to a piece of furniture, his repair would have outlasted the original. Approximation and fixation are essential; but these are only means to an end: the union of the fragments by the production of new tissue from one to the other.

I have tried to trace the reparative processes, following the introduction of the bone graft, from the formation of granulation tissue to the incorporation of the graft as an integral part of the host tissue. There are processes that go beyond the limits of anatomy and physiology. We know that all tissues react to changes in environment. A fractured bone manifests the greatest reparative power during the period immediately following the injury. Since injury thus stimulates repair, it is clear that the freshly removed graft has potentialities for repair that will become fully manifest as soon as it can establish its vascular connections. This reaction to environment takes

the form of increased metabolism. As the graft takes on its function of immobilization, its metabolism is further stimulated by the demands of its new environment. The adaptive response is increase in size and strength, and this is just what occurs. Later, the graft must adapt its structure to its new position and the stresses it encounters. Thus function determines structure, and modification of function brings about modification of structure.

Other grafting methods. The intramedullary graft has not justified the early hopes of those who advocated it. Henderson would appear to be unduly optimistic, however, when he states that it has been given up. Rather faint hearted recommendations of it are still occasionally seen. At its best, the method is applicable only to the largest bones: the femur, the tibia, and possibly the humerus. In all cases where eburnation and sclerosis extend back for a long distance, the limb must be materially shortened or the graft must be left lying loosely in a hole through bloodless bone. This operation was first advocated after experiments on a cadaver; the practical test of it has shown that the conditions in the living body are, or should be, entirely different. Granting that the marrow is the most important source of blood supply for the uniting structures, the process of reaming it out is manifestly very prejudicial to union and is contra-indicated. The technique makes accurate coaptation of graft and host impossible, so that vascularization of the graft is uncertain and defective; nor is there any strict immobilization, since all the graft does, or is expected to do, is to prevent gross lateral displacement. The most fundamental objection to the method is that dissimilar elements of bone are approximated, in violation of the biological principles of bony union.

Failure of union after the application of an intramedullary graft is an unusually vexing problem because of the destruction of the marrow and the consequent aggravation of the ischæmia of the fragments generally.

CASE 8. As the result of a motor accident a year and a half before I saw him, this young man was suffering from non-union of the right tibia. Casts had been repeatedly applied with no result (Fig. 11 A). About a year after the accident an intramedullary graft had been used. Figure 11 B shows how disastrous the operation was to the medullary circulation and how ineffective it must have been; the graft was too short and too small to immobilize the fragments and too irregular to maintain effective connection with what little vascular supply the reaming of the marrow had left. Amputation had been eventually recommended.

I inserted an inlay graft from the sound tibia. The result 2 months later is shown in Figure 11 C. Callus was slow in forming at first and the cast was maintained for 10 months and then exchanged for a brace. Within a year the condition was excellent (Fig. 11 D). It is now 2 years after the operation and there has been no trouble with the graft.

A study of the roentgenograms in this case will reveal, more clearly than words can, the difficulties attending the insertion of an intramedullary graft and the objections to its use.

CASE 9. This patient was 39 years old. He had fallen about 28 feet, 6 months before, and fractured the right humerus in three places. After closed treatment for nearly 3 months, an intramedullary graft had been inserted in an attempt to promote union of the middle fracture. After 3 months in a cast, the patient came to me because of failure of union.

When I saw him there was most free motion at the site of fracture and considerable bowing of the humerus. The roentgenogram showed entire failure of union. From an inspection of the roentgenogram in Figure 12 A, one can learn not only how useless the graft was but also the uncertainty of immobilization by such methods. The figure shows how the marrow has been destroyed and reamed out to make room for the graft and how the latter is lying loosely in two hollow cylinders of calcium phosphate, without either mechanical or physiological justification for hope of its success.

I considered this a suitable case for the onlay graft, since the marrow was gone and the endosteum probably damaged, if not destroyed. This apparently succeeded as is shown by the roentgenogram taken 2 months later (Fig. 12 B). Five weeks later, however, there was evidence of failure and the roentgenogram showed the graft cracked and apparently loose at the lower end.

There was now no recourse but the inlay graft. At this operation the old intramedullary graft was found free, having failed to unite with either humeral fragment. The inlay was apparently successful, although callus developed slowly. Four months after operation the arm seemed solid, but, a few weeks later, there was motion at the site and a small crack was evident in the graft.

This case is still under consideration and is recorded because it illustrates, not only the futility of the intramedullary graft, but the prejudicial effect this has on union by any other means. I have already referred to the necessity for utilizing every source of blood supply, and to the reason why re-

striction of blood supply militates against the success of the inlay graft. It is probable that lack of blood supply so retarded the process of assimilation that the graft, instead of reacting properly to Wolff's law, gave way before the strain of function. It is only fair to say, however, that the graft was subjected to a more severe strain than it should have been in any case: the patient admitted that he was shoveling coal when the fracture occurred.

In its early course, this case controverts the argument that non-union has a constitutional cause. Of three fractures in the same bone, two united and one failed to unite. How much non-union may have been dependent on the technical difficulties of early immobilization and how much it was favored by the ill advised use of the intramedullary graft can only be estimated; but the fact that union failed in the middle fragment, which was cut off from direct vascular connections at both ends, illustrates how dependent union of bone is on abundance of blood supply and how the periosteal circulation, supplied by the muscles attached to the bone, may be unable to meet the demands of repair, especially if the soft tissues have been lacerated by a crushing injury, as in this case.

The osteoperiosteal graft, first advocated by Ollier, violates the principles governing the union of fractured bones. Since the periosteum normally supplies only one-third as much callus and blood as the endosteum and marrow, the nutrition of the graft is restricted; callus formation is limited correspondingly. In pseudarthrosis, the periosteum and usually the overlying soft parts as well share in the general ischæmia of the structures and may be practically bloodless. The inadvisability of applying a graft to a structure of such low vascularity should be evident, particularly when the inlay method provides contact with all the elements of the host bone and taps every available source of blood supply. The osteoperiosteal graft provides no mechanical continuity since it consists of soft tissue to which plaques of bone cling. It, therefore, cannot exert an immobilizing effect and, on that account, cannot be influenced by Wolff's law.

These objections apply to the onlay graft as well, except that anatomical continuity is preserved. The blood supply is maintained only through the cortex which is not well adapted to vascular anastomosis and does not normally provide any considerable portion of the circulation for callus formation, as has been explained. The method is biologically unsound because it provides for contact of only one of the elements of bone, namely the cortex. Further, the strength of the graft must be diminished by the necessity of drilling generous holes for its fixation by means of either autogenous pegs or screws or screws of metal or other material which has a destructive effect. The use of boiled bone is especially to be condemned; its osteolytic effect has been demonstrated both experimentally and clinically. If the onlay graft is ever used, it should be fixed with pegs or screws of autogenous bone.

Fracture of an onlay graft is a catastrophe, because it then becomes no better than an osteoperiosteal graft without its periosteal vascular connections. When the onlay graft is used, there is always the difficulty of covering it with skin and subcutaneous tissue, especially when it is applied to the bones of the forearm or the tibia. It is often a case of choosing between covering it incompletely and using undue tension in approximating the soft tissues over it. Any procedure which increases the original diameter of the bone is, in this respect, hazardous.

Instead of the osteoperiosteal graft, I would use the sliver graft which has mechanical continuity, contains all four bone layers, and responds to Wolff's law. It can be taken from the side of the gutter where the large graft is obtained. Being thin, it can adapt itself to the contours and pressures of surrounding parts. It is a question whether, if the motor saw had existed in Ollier's day, he would not have used the sliver graft.

OTHER OPERATIVE METHODS

Step-up operation (*Senn*). The step-up operation is faulty in conception and unfortunate in results. If union failed, either at the time of original fracture or at subsequent open operation, in spite of reasonably accurate approximation of the fragments, it is not likely that, in their sluggish state, the elements of pseudarthrosis will be able to unite. The argument cannot be used that the stimulating conditions of fresh fracture are reproduced by the operation, unless all of the sclerosed and ischæmic bone is removed. Hence the greater the shortening the better the chance of union.

Shortening is demanded not only by the necessity of getting back to normal bone but by the demands of the operation, since overlapping necessitates shortening. To be carried out with a reasonable chance of success, the operation requires at least 4 inches of shortening.

CASE 10. This illustrates a case in which the Senn "step" operation for ununited fracture of the humerus failed. Figure 13 A shows the fragments fixed by a Parmelee band. The wire had been inserted at a subsequent operation. I removed the metal and inserted an inlay graft. The result is illustrated in Figure 13 B which shows proliferation of the graft. The ultimate result was excellent: it is now more than 2 years after the operation.

In this case, the bone had been considerably shortened and length of the limb sacrificed all to no purpose. The roentgenogram shows, not only the large amount of metal applied, but its destructive effect on the bone.

Mechanical fixation. Suturing, wiring, nailing, and plating, following freshening of the ends of the fragments, are based on little but mechanical principles. If the osteogenetic power of the fragments, after the trauma of freshening, is at a high level, and if immobility is well maintained, union may occur. Such methods, therefore, leave much to chance; and the chance that osteogenesis will be vigorous and rapid in the bony members of a pseudarthrosis is not great. Suturing has the advantage that it is not so depressing to osteogenesis as the introduction of metal. Plating has the advantage of ensuring immobility, at least until the absorption of bone defeats its purpose. All foreign bodies have the disadvantage that they not only cause absorption of the bone with which they are in contact but that they favor low-grade infection which inhibits union.

There is no doubt but that metal plates bring about union in favorable cases of fresh fracture but it must be clearly understood that they are never indicated in pseudarthrosis. Lane states that few surgeons appear to have sufficient mechanical knowledge or experience to deal effectively with fractures by operative procedures. He would thus appear to realize that his method is not successful in the hands of most surgeons. The failures are not always due to faulty mechanics; Lane himself follows a most rigid aseptic technique, and Sherman makes the following emphatic comment: "The most scrupulous, aseptic technique is necessary if infection is to be avoided. Unfortunately, few surgeons have been sufficiently interested in this operation and technique to organize operative teams along the lines absolutely necessary if success is to be secured. One rarely finds this very rigid technique in practice except in a few clinics where open operation has been given special thought and attention. The surgeon who operates rarely in such cases finds it rather awkward and difficult to carry out such technique in detail, and as a result, he is prone to blame the plates, screws, catgut, or operating room nurse, when infection occurs. Seldom does he look to himself or consider himself a causative factor."

Even comparatively innocuous infection, combined with the osteolytic influence of the foreign body, may prove sufficiently virulent to check union. If the fragments do not unite speedily, while osteogenesis is at its highest level, or if infection of any grade sets in, the plates must be removed and some method used which is based on sounder principles. The failure of Lane's method in the treatment of pseudarthrosis is attributable to careless technique, inaccurate application of the plates, and the use of too much metal, as well as to the inadequacy of the principles on which it is based. The method is justified in the treatment of fresh fracture only when the surgeon is highly skilled and controls a group of assistants and nurses whose training and facilities will ensure the most scrupulous asepsis and the most exact technique. It is under such conditions and by means of perfect apposition of the fragments, allowing end-to-end stress, that success has followed the use of these plates.

Sherman has carrried out the principle of mechanical fixation in a great number of cases of fresh fracture with outstanding success, attributable not only to the exactness of his asepsis and perfection of his surgical environment, but to his care with the mechanical details of the operation. The most important of the latter is, I think, the self-tapping screw. The original wooden screw was conical and

was held in place by its own compression on being driven into the bone. The pressure on the bone being "equal and opposite," the bone gave way and allowed the screw to loosen and even fall out. Sometimes the screw split the bone, as it always tended to. Sherman's screw does not taper and hence has no tendency to split the bone. It taps the hole drilled in preparation for it; that is, its sharpened thread makes a spiral groove in the side of the drill hole which the rest of the thread fills as the screw is driven home. The screw is thus not held by compression but by the engaging thread alone; and the bone is under no compression. If metal screws are ever used in the treatment of non-union, they should be of the self-tapping kind.

Plates of dead bone have no advantages over metal screws; they are made of lime salts instead of metal. Boiled bone is dead.

The use of silver wire persists because of two wrong impressions. Fixation with such unabsorbable material gives some surgeons more confidence in its permanency. As a matter of fact any such fixing agent has entirely served its purpose in a few weeks, and proper absorbable material will last that long. The surgeon who does not know and trust suture material has some justification for preferring a metal which he understands, or thinks he understands. Even he, however, should realize that foreign material in contact with bone is not desirable; after its work is done its presence is positively undesirable. I cited a case years ago that illustrates this point. Fracture had been treated by Lane's plates held in position by a silver wire encircling one fragment below the fracture. The work was well done and the fracture united perfectly. Six months later there was a spontaneous fracture of the same bone at the point of the encircling wire; the silver wire had caused the bone to melt away gradually.

CASE 11. This patient, a woman 30 years of age, had been seriously injured in a motor accident almost 3 years before I saw her. Meantime, various methods had been used in the attempt to unite the fracture of the right radius; casts, splints, and operative measures had been tried, including two attempts at bone grafting. Figures 14 A and B show the early and late results of one of these efforts. As shown in Figure 14 A, the attempt to insert a tibial graft into the medullary canal had split the lower fragment, in addition to the obvious and inevitable destruction of the marrow before it was inserted. Figure 14 B shows absorption of the split-off segment as well as of the graft itself. Union of the graft has progressed no further than might have been anticipated. The bone is badly out of alignment and the carpus distorted.

I saw the patient shortly after this roentgenogram was taken. Non-union was evident. The hand was fixed in pronation and radial adduction and could not be rotated even passively.

I inserted a double-wedge-end inlay graft from the tibia. Figure 14 C shows the result 10 weeks later. Alignment was restored and the hand is now in proper position. This is a recent case, but massage promises to restore normal function now that union is solid.

As I have observed, the intramedullary graft, inadvisable in any case, is out of the question in non-union of the smaller long bones. If proof of that were needed, this case supplies it. The marrow cavity is too small to hold a graft of sufficient size and strength.

CASE 12. Although I have reported this case before, I mention it again to show to what extremes the desire to saw off the bone and rely on metal fixation may be carried. It was a case of oblique fracture of the tibia. Instead of making use of this relationship of the fragments, the surgeon cut off a considerable amount of bone until both fracture faces were horizontal. Then he wired the fragments with silver wire. The wire broke and alignment at the end of 3 months was considerably worse than at the beginning. To non-union had now been added malalignment, marked shortening, and the presence of useless foreign bodies. Three operations of this nature had been performed with more and more shortening each time.

I used a sliding inlay graft with an excellent result.

A much more common proof of the disadvantages of permanency of fixation material is the incidence of infection. Low grade infection may be latent at the time of operation, or may be carried in from the skin; in either case the presence of the foreign body contributes materially to the chances of its development. Even when there is no local infection, the foreign body, by devitalizing the bone, makes it a possible nidus for any hæmatogenous infection; such are not as rare as was once thought. Many years ago, before the introduction of kangaroo tendon, I used silver wire to fix the fragments of a fresh fracture of the humerus. Everything went well for 10 years, when an abscess developed about the wire.

So much for the consideration of permanency. The other wrong impression is in regard to the strength of silver wire. Naturally one has in mind the difficulty of maintaining reduction in the face of muscle pull. I investigated the tensile strength of various sutures and wires some years ago, and the results may occasion some surprise even yet. Kangaroo tendon has a higher tensile strength than silver wire of comparable weight, and the knot stands more tension without slipping.

USE OF THE AUTOMATIC MOTOR-DRIVEN SAWS

The motor with its sterilizable shell and attachments has been described in full elsewhere (1). In my first designs the motor was not powerful enough for all purposes, and the use of a flexible shaft was suggested, in order that a heavy fixed motor might be used. The motor of my design was improved and made adequate long since, but the flexible shaft is still used by some surgeons, inadvisedly I believe. There is a limit to the power which a flexible shaft will carry, and either power or flexibility must be sacrificed. In fact, if the motor is powerful enough to drive the twin saws through the adult tibia, the shaft cannot be flexible. At the best, the tool, whether drill or single or twin saw, vibrates and "chatters," evidence of which is borne by the cut boneface. When the tool is carried by the fixed armature shaft, it cuts evenly and straight and the weight of the motor (4 pounds), to which theoretical objection might be taken, serves to steady the tool and absorb the vibration. As a result, the cut surface is smooth and even, the advantages, and even necessity, of which are evident from the discussion of coaptation and the physiology of bone union. The portability of the instrument, while not as important as it once was, is still a consideration in smaller hospitals.

The saws must be sharp and must be replaced, just like the blades of a safety razor, as soon as they become in the least dull. The worst fault is inequality of the cutting edges of the teeth. If a saw has touched an instrument, such as a retractor in the wound, it will immediately bear obliquely and no force will hold it straight. Even the twin saws will not run parallel but will bend under the unequal resistance; the result is a graft of uneven thickness. Once a revolving saw has touched an instrument or has come under suspicion for any other reason, I never experiment with it.

The actual cutting of bone is mechanic's work. An accurate tool tends to hold to the line; one must not have the feeling of forcing it constantly to the line. One cannot saw a board that way; one cannot even draw a straight line in such piecemeal fashion. A surgeon with sufficient mechanical sense will trust his tools and work free-hand; but if he will trust them he must respect them and know their ways. If the saw is pushed too fast, it will not clear itself and will jump.

One sometimes sees a surgeon drawing the saw back and forth over the cortex, gradually working toward the marrow. That is a poor way to saw, not only because it is hard to hold the line in this way, but because the dense cortex will heat the saw. This is one of the results of timidity; swift cutting with sharp tools produces no destructive heat if carried out properly. The saw should be driven through to the marrow at the outset and the line followed through the entire thickness at once (Fig. 5). This has the advantage of plunging the saw into the marrow fat, which serves as a natural lubricant so effective as to render the use of the saline drip (supplied by either an aural irrigating bulb or a gauze sponge) merely auxiliary.

I have seen many specimens of grafts when cases of failure of grafting have come to me. In one such, the crest of the tibia had been used and had been removed in a sliver of varying thinness by means of a single saw, either motor driven or hand driven. The wavering irregular saw line suggested that both motor power and hand power had been used, the latter too freely. The saw had been crowded, both forward and back and forth toward the line. I would not wish to represent bone sawing as a formidable mechanical procedure. Every surgeon should have enough mechanical gift to saw a board straight, and he should readily acquire knack with his hands in a new procedure.

PRE-OPERATIVE MANAGEMENT

Reference has been made to the necessity for postponing operation if the bone has been

recently infected. If the history suggests the presence of latent infection, it is better to disclose it, by means of deep massage with manipulation of the fragments, than to have a recrudescence after the insertion of a graft. The infection is eradicated by surgical means and grafting not undertaken until the lapse of sufficient time after healing.

CASE 13. The non-union in this case followed severe crushing of the right arm in a man aged 29 years. A fracture of the forearm had united after open treatment. The humerus was treated first by traction, then on two occasions by bone graft. The graft broke both times, the second time during manipulation. Infection had been present to a varying degree until 2 or 3 months before I saw him. Figure 15 A shows the result of one of the early attempts at bone grafting, and B the condition when I first saw the patient.

I first tried suturing with kangaroo tendon after resection of the scar tissue but, 2 months later, there being no union, I inserted a graft from the tibia. Infection recurred and the general condition was serious for some weeks. Transfusions of blood were given. The condition of the graft 10 weeks after operation is illustrated in Figure 15 C. The wound eventually healed, but 5 months after the operation again broke down and discharged and a sequestrum separated. The infection was controlled but the graft had been destroyed in the infected zone (Fig. 15 D). Five months later there was still no union and a second graft was inserted. Four months later union was firm (Fig. 15 E). Ten months after the operation the patient fell and injured the arm severely enough to cause a hæmatoma but the graft withstood the shock.

This case illustrates the necessity for caution in approaching bone in which infection has been recently active. More than 2 months had elapsed before the attempt at suturing the fragments. A bone graft was not inserted at the first operation, because the main purpose at that time was to resect the anæmic scar tissue in order to provide a healthier environment for the non-union. The fragments were sutured in the hope that restoration of circulation might promote union. If it would not, I intended, according to my invariable practice, to wait for complete restoration of circulation before venturing to inlay a graft.

The more extensive inlay operation, 5 months after the subsidence of the infection, brought about a recrudescence which not only destroyed part of the graft but seriously threatened the patient's life. I waited 9 months after the subsidence of this infection before attempting a second graft. This time there were no complications and an excellent result followed, which has persisted up to the date of writing, a year and a half after the operation.

When the infection destroyed the center portion of the bone graft, I inlaid a second graft in the fragments of the first. The original graft was not dead. In a series of such cases, I have never found the original graft dead. As a matter of fact, it bleeds most profusely when cut with the saw. Thus does practical surgery confound the theorists.

If, in the survey of the case, the presence of extensive scar suggests that the graft cannot be surrounded by well vascularized tissues, the scar should be removed and replaced by an ample pedicle graft usually taken from the other limb. The bone inlay operation should not be undertaken until at least 1 month after the completion of the pedicled graft procedures.

The immediate pre-operative care is of the greatest importance. It is carried out for 24 or 48 hours. In my own practice the iodine preparation is always used.

TECHNIQUE

The bone graft operation. In all cases in which it is necessary to have the limb under mechanical control, the patient is placed upon the Albee fracture-orthopedic table for management, not only throughout the operation, but during the postoperative immobilization by plaster of Paris. The patient is, of course, anæsthetized to the point of muscular relaxation, spinal anæsthesia being used frequently for the lower extremities.

The fractured area is exposed by a generous skin incision. If scar is present but not too extensive, the incision should be made through healthy tissue when possible. The incision is made large enough to provide access to the pseudarthrosis without undue traction on the soft tissues. When the fractured bone is superficial, as in the case of the tibia, the incision is made lateral to the intended site of the bone insert. The skin and subcutaneous tissue are retracted and the bone ends are delivered and freshened with osteotome, motor burr, or saw. Anæmic scar tissue is carefully dissected away so that vascular tissue will come in contact with the graft. The periosteum is divided with a knife longitudinally over the bone to be removed in making the gutter for the bone insert. Periosteal flaps are turned back to either side and the bone exposed.

Two longitudinal parallel saw cuts, about ⅜ to ½ an inch apart, are made in the frag-

ment ends completely through the bone cortex to the marrow cavity with a motor twin circular saw. The distance between the saw cuts is arranged by adjusting the distance between the twin saws. These cuts are made from 2 to 3 inches into the end of each fragment from the line of fracture. While the fragments are held in good alignment, these cuts should always extend far enough from the line of fracture to reach well into the non-sclerosed active bone of each fragment. This distance is subject to considerable variation, depending upon the site of fracture and the extent of eburnation present. The distance the twin saws should be apart, i.e., the width of the gutter for the graft, should vary according to the size of the marrow canal at the smallest diameter of the fractured bone involved in the cuts. With the small motor drill, holes are bored in the cortex on either side of the gutter to receive the smallest sized kangaroo tendon which will answer. These holes are placed near the line of fracture so as to fix the center of the insert.

The exact length of the desired inlay is obtained by measuring the gutter and transferring this measurement to the anterior surface of the tibia after its exposure. A flexible probe is usually satisfactory for this purpose, a right-angled bend marking the exact measurements. I have often used the carpenter's calipers. The wound and gutter are packed with hot saline compresses while the graft is being prepared. The graft yielding tibia is exposed by an incision over its crest. The overlying structures are retracted, and the size and shape of the graft are outlined in the periosteum by means of the scalpel with the probe measure and twin saw as a guide. With the twin saws adjusted to the same distance apart as when cutting out the gutter, plus the thickness of one saw blade, bone cuts are made to the marrow cavity along the anteromesial aspect of the tibia. The saline drip is used by either of the means mentioned. With a small motor driven saw, the graft is now cut at the ends and dislodged by the osteotome. The graft, thus made of sufficient length to extend to the end of the gutter, will have generous contact with the vascular marrow substance and normal bone cortex on either side of the point of sclerosis and non-union. In this way the marrow substance upon the graft has its best chance to be penetrated by host blood vessels and to act as a vessel conducting agent. An accurate fit is assured by the adjustment of the twin saws which are used both in the shaping of the gutter and in the formation of the graft.

Strands of kangaroo tendon passed through the drill holes previously made are raised on a long clamp from the bottom of the gutter, allowing the graft to be inserted beneath each of the four loops. By tapping the author's bone set (of which the carpenter's nail set is the prototype) against different regions of the graft, with gentle blows of the mallet, the graft is firmly seated in its gutter. The kangaroo tendon is then tied, care being taken that a secure knot is used; the last half of the knot is held by a ligature of chromic catgut No. 1 tied at right angles to it to prevent any possibility of the knot untying under excessive stress. In this respect, however, the conditions are most favorable in that two strands of the kangaroo come over the graft at each of the four points. The site of the fracture is covered with the periosteal flaps which were reflected to expose the bone to be removed. This gives two layers of periosteum covering the transplanted fragment. The overlying tissues and skin are closed without drainage. It is most important that the tissues covering the graft be under no tension. No trouble results in this respect when the inlay is used, inasmuch as the diameter of the bone is not increased at the site of operation. All sutures should be absorbable and no larger than actually necessary.

The soft parts are approximated with continuous suture of No. 1 chromic catgut; the skin is closed with continuous suture of No. 0 plain catgut. The line of suture is puddled with 3.5 per cent tincture of iodine splashed into the line of suture by means of blows of a completely saturated sponge on the end of an instrument.

Sliding graft. In most cases the graft material is obtained from the tibia. If, however, the bone involved is a large one such as the femur, tibia or, possibly, humerus in the adult, and the conditions are favorable for the use of

the sliding graft, the twin saw enables a technique to be carried out whereby the graft is slid from one fragment to the other. This graft and the gutter in the receiving fragment may be formed completely by the twin saw, or the twin saw may be used merely as a marker and the single saw used with converging saw cuts, so that, in the latter instance, the graft has a semi-wedge cross-section and its depression below the surface of the recipient bone will ensure a tighter fit. Otherwise the technique is identical with that of ordinary inlay.

Double-wedge-end graft (*Fig. 21*). Whenever the bone fragments are small and conical in section, such as in the forearm in the adult, or when the bones are small or conical-ended in children, I have advised and employed for many years the double-wedge-end graft. In this instance the twin saw is not used at all. The wedge-shaped gutter is shaped by a single saw in a very similar manner to the gutter made by the twin saw. In this instance, however, the surgeon will have to use his judgment in determining just how large a wedge should be removed from either fragment. If the bones are especially small, the wedge-shaped cavity is enlarged by splitting the bone fragments longitudinally by means of a thin osteotome thrust into the apex of the wedge-shaped gutter distally to the point of non-union. This causes the wedge-shaped gutter to spread so that it will receive a stronger graft of larger diameter at its center which determines its immobilizing strength. The drill holes are made precisely as in the ordinary inlay operation. A pattern of the graft is then mapped out upon the anteromesial surface of the tibia to measurements taken of the enlarged wedge-shaped gutters just made in the fragments. With a single saw a graft of the complete thickness of the cortex is removed. The technique of insertion is precisely the same as in the ordinary inlay, but the procedure is simplified by the use of tin clips. The size and strength of the graft must be ample. The sole object of the wedge-shaped contour is to provide a means of inserting a larger and stronger graft.

Case 14. This patient had been in a serious accident 2 years before I saw him. He was sent by the Pennsylvania Railroad. The right radius and ulna had been fractured (Fig. 16 A). Numerous attempts to promote union had been made: (1) September 16, 1923, splinting under anæsthetic; (2) October 22, 1923, open operation to freshen the ends of the fragments; (3) January 29, 1924, application of metal plates; (4) April 25, 1924, removal of plates and insertion of bone-grafts; (5) February 24, 1925, kangaroo suture of fragments; (6) March 9, 1925, fragments wired, after marked resection of bone ends, according to Senn's recommendation.

Figure 16 B shows the failure of the grafts inserted in April, 1924; this X-ray film was taken 3 months after; C illustrates the result after another interval of 3 months, and D the result 5 months later; E was taken 10 days after the suturing operation in February, 1925.

The patient came to me 5 months after the last operation. I inserted a double-wedge-end inlay graft in the fragments of each bone after removing the wire. Union was slow but eventually became solid. Massage was used to stimulate union and restore joint function. Three months after the operation, union was solid and movements of the elbow and wrist fairly satisfactory. The result 6 months after the operation is shown in Figure 16 F. It is now 4½ years after the operation and he is actively employed by the railroad.

Two years after the operation, the case was presented and the result demonstrated before the Association of Surgeons of the Pennsylvania Railroad. I attributed the failure of the earlier operations to the faulty methods used. Bone had not only been destroyed by the injudicious use of metal but had been cut away *en masse* during the Senn operation. Such methods cannot be described as anything but meddlesome surgery. In general, the early treatment indicates a mechanical, and therefore a short-sighted and one-sided, view of the nature and treatment of non-union.

Case 15. This patient was 56 years old when first observed, 3 months after she had slipped and fractured the left radius and ulna. A cast had been worn for 6 weeks, and then traction had been tried. Then, at an open operation, the fragments had been sutured with kangaroo tendon. Non-union had developed when I first saw the patient (Fig. 17 A).

I inserted a double-wedge-end inlay graft in the fragments of each bone, because the fragments were not large enough in diameter to receive grafts of sufficient strength if shaped and inserted according to the ordinary inlay technique. Supplementary sliver grafts were also used. The roentgenogram taken almost 3 months later (Fig. 17 B) showed excellent union. Function was completely restored and has remained unimpaired to date, nearly a year after the operation.

In this case, a window had been left on each side of the cast for the application of diathermy. The loss of immobilization had more importance than the uncertain effect of diathermy. The surgeon, I fear, sacrificed the substance for the shadow—

almost literally. Windows are made in casts for various reasons, none of which is sufficient to justify the sacrifice of immobilization. I have by chance had the opportunity of judging the efficacy of diathermy in a large number of cases in which it had been used by others. In many cases it had been given for long periods, in one for a whole year. There was no evidence, either clinical or by roentgenogram, that it had caused any stimulation of osteogenesis.

CASE 16. The patient, 63 years old, had fractured the right radius and ulna 2 months before. Open operation had been performed a few days later. The non-union, when I saw her, is illustrated in Figure 18 A.

I inserted a double-wedge-end inlay graft from the tibia into the fragments of each bone (indicated by arrows in Figure 18 B). Two months later the condition was satisfactory and the cast was left off. Three weeks later the patient was dismissed, the result being considered excellent. It is now almost 4 years after operation and the arm has functioned well (Fig. 18 C).

The promptness of union and the excellence of the result would surprise those who adhere to the belief that advancing years present a serious obstacle to the union of bones and grafts.

In all cases the limb should be splinted in plaster of Paris applied so as to immobilize the joint above and the joint below. Too much emphasis cannot be laid on the importance of the careful application and molding of the plaster. It should be done either by the surgeon himself or by a well trained assistant on whose skill the surgeon can rely. Proper immobilization after the operation is even more important than after the reduction of a fresh fracture. In both cases laxity permits hinge movements at the site of fracture, but after the application of a bone graft it allows either rocking of the graft in its gutter or its displacement from the gutter, and results in fracture of the callus and disruption of the vascular bridges between graft and host.

A suitable orthopedic table, such as that designed by myself (Fig. 19), greatly facilitates the application of plaster or other dressing. Figure 20 shows a shoulder spica extending to the wrist. This was applied while the patient was in the position illustrated in Figure 19.

POSTOPERATIVE TREATMENT

The cast should not be disturbed for 8 weeks. If non-absorbable sutures have been erroneously used, no harm is done by their actual removal or by cutting a window in the cast; the harm is done by removing the splint padding and dressing from over the line of suture. This disturbs the equality of splint pressure and ruins the immobilizing influence of the cast. A window is liable to cause œdema which produces increasing pressure and stagnation and may seriously disturb the nutrition of the healing bone (Fig. 22).

When the cast is bivalved and removed, the limb is carefully and gently tested for consolidation. The region of fracture is then roentgenographed. If union is not complete, immobilization is continued with the bivalved cast. This is removed daily for massage not only of the area of operation but widely over the limb, the object being to stimulate the circulation and callus formation. If consolidation is not complete in a reasonable time, a brace may be so applied as to allow function without too much lateral stress on the point of non-union. A surgeon is more efficient if he is able to design braces; he should at least be able to advise the maker and consult intelligently with him.

In many cases in which osteogenesis is slow, the critical period is during the stage of restoration of normal bony structure in the callus. As has been pointed out, the callus does not attain its full powers of resistance until the trabeculæ have been rearranged in conformity with those of the host bone. In slow cases, this process may be delayed long after the callus has become hard and the limb apparently firm. It is during this period that physiotherapy is being used to stimulate enlargement of the graft and to restore full movement to joints after their restriction in casts; or the patient may be allowed to bear weight or carry his arm without support. It is obvious how carefully physiotherapy should be supervised and how gradually the patient should be allowed to bear weight, since weight bearing is one of the stresses which influence the trabecular reconstruction of the callus and the graft. Manual examination for consolidation should not be repeated too often. If the surgeon will keep in mind the various stages of repair, and not think of callus as a kind of glue that has set, he will be able to visualize the process of union and suit his postoperative cases to actualities. It is not always easy to steer a safe course since (1) full function

should not be allowed until union is complete and (2) the processes of union are not complete until the new bone has been molded by the stress of normal function.

In all cases the after-treatment must include much physiotherapy; the interval since the original fracture has been so long that joint stiffness and tendon adhesions are only overcome with difficulty. Baking and diathermy are followed by manual massage which is the most difficult, the most important, and the most exacting. The services of an expert (preferably a woman) are necessary. In 25 years I have become more and more convinced that only a woman can control a patient satisfactorily and so direct his mental reaction that he will not fear manipulations, but will surrender the limb without that sense of distrust which will engender muscle spasm and entirely defeat the objects of manipulation. Physiotherapy demands unusual qualities of mind as well as manual skill. There can be no formula since progression depends on the development of union, which only an experienced surgeon can gauge. The nature and extent of physiotherapeutic treatment must be determined, therefore, by the surgeon who maintains intimate acquaintance with the case and close co-operation with the masseuse. In most cases in which the graft fractures or breaks away from its attachment to the host bones, the fault lies in careless supervision of convalescent treatment or adherence to a routine in physiotherapy.

REVIEW OF CASES

To illustrate the general nature of the cases one may expect to treat, the complications one encounters, and the advantages of the inlay bone graft method, I am presenting 754 cases of non-union. The site of fracture, the method of treatment, the complications, and the results are presented in the Table.

The humerus was involved in 201 cases, the radius or ulna (usually both) in 162, the femur in 121, and the bones of the lower leg in 270.

The nature and difficulty of the cases is revealed by the number of operations performed before the cases came under my observation. Operations, from one to five in each, had been performed in 317 cases. A few of these were

TREATMENT AND RESULT IN SEVEN HUNDRED FIFTY-FOUR UNUNITED FRACTURES WITH OR WITHOUT LOSS OF BONE DURING THE PAST TWENTY-ONE YEARS

		Cases
Site of fracture		
Upper arm		201
Forearm		162
Thigh		121
Lower leg		270
Loss of substance		
None		676
Present		78
Previous operation		317
Type of operation		
Inlay graft		541
Sliding graft		198
Inlay with osteotomy		4
Fibular graft		3
Wedge mortise		1
Preliminary skin pedicled graft		19
Plastic on graft		6
Postoperative complications		
Infection		18
Wrist-drop		4
Fracture of graft		9
Re-union of graft without operation		4
Results		
Good	(89 per cent)	671
Poor	(11 per cent)	83

No case has been included in the series in which there was not a complete non-union or pseudarthrosis and also no case has been classified as a success in which union has been present less than 6 months.

for sequestrectomy following infection, but in the main they consisted of the insertion of wire, bands, plates, or bone grafts of various types. As a rule they went in pairs: application of the metal and, later, removal of it. In some cases these foreign bodies were revealed when I operated, sometimes clinging to dead bone, sometimes in a well of pus, but always a tribute to the persistence, if not the good judgment, of the operating surgeons.

Ununited fracture of the humerus naturally brings up the question of the musculospiral nerve, especially in a series such as this in which previous operations had commonly been performed. If musculospiral paralysis was present before operation, I classed the result as good if otherwise, satisfactory; in some of these, however, successful treatment was carried out by a neurological surgeon. Wrist-drop occurred after the inlay operation on the humerus in 4 cases.

The graft broke or gave way in 9 cases, in 7 of which it reunited and a good result was obtained. In one case, in which a long graft

had been inserted into a tibia largely destroyed by osteomyelitis, the graft bowed and plastic operations were necessary to straighten it.

The ultimate result was good in 671 cases (89 per cent) and poor in 83 (11 per cent). In all of these cases the percentage of cure by all methods had been zero; and the percentage of cure in 317 of them, by operative measures, had likewise been zero. It seems superfluous to point out the advantages of the inlay bone-graft method.

REFERENCES

1. Albee, F. H. Orthopedic and Reconstruction Surgery. W. B. Saunders Company, 1921.
2. Bancroft, F. W. Process of union after fracture. Ann. Surg., 1929, xc.
3. Blaisdell, F. E., and Cowan, J. F. Healing of simple fracture. Arch. Surg., 1926, xii, 3.
4. Clark, A. H. The effect of diet on the healing of wounds. Bull. Johns Hopkins Hosp., 1919, xxx.
5. Dieterich, H. Histogenesis of callus. Arch. f. klin. Chir., 1926, xcli.
6. Garlock, J. H. Tendon grafts. Ann. Surg., 1927, lxxxv, 1.
7. Kay, H. D. Function of phosphates in bone formation. Brit. J. Exper. Path., 1926, vii, 177–180.
8. Lane, W. A. Med. J. & Rec., cxxi, 261.
9. Leriche, K., and Policard, A. The normal and pathological physiology of bone: its problems. Translated by Moore, S., and Key, J. A. St. Louis: C. V. Mosby Company, 1928.
10. Martland, M., and Robison, R. Possible significance of hexose-phosphoric esters in calcification; bone phosphatase. Bio-Chem. J., 1927, xxi, 665.
11. Robinson. Healing of fractures. Arch. Surg., 1928, xvii, 420–428.
12. Robison, R. The possible significance of hexose-phosphoric esters in ossification. Bio-Chem. J., 1923, xvii, 286–293.
13. Robison, T., and Soames, K. The possible significance of hexose-phosphoric esters in ossification: the phosphoric esterase of ossifying cartilage. Bio-Chem. J., 1924, xviii.
14. Sherman, W. O. Operative treatment of fracture of shaft of femur with maximum fixation. J. Bone & Joint Surg., 1926, viii, 494–503.
15. Speed. Non-union after fracture. Ann. Surg., 1929, xc.

PRIMARY AND SECONDARY OVARIAN CANCER[1]

A Histogenetic, Morphological, and Clinical Study

M. R. ROBINSON, M.D., F.A.C.S., New York
Attending Gynecologist, Beth Israel Hospital, New York; Chief in Gynecology, Beth Moses Hospital, Brooklyn

THE problems of histogenesis and classification of primary ovarian cancers and the differentiation of the primary from the secondary types, have occupied the attention of the foremost histopathologists since the dawn of cellular pathology; and yet we find our knowledge in these fields encumbered today with as many diverse interpretations and extraordinary conjectures as then.

The dominant histogenetic theory about ovarian neoplasms, which tradition has sanctified into an axiomatic truth, is the "embryonal rest" theory of Cohnheim. A painstaking study of the best contributions to this subject reveals that the adoption of this theory rests mainly upon suppositions and inferences, instead of direct histopathological facts showing a structural continuity between these rests and the neoplasm to which they are supposed to have given rise.

The want of histogenetic clarity has also dimmed the subject of tumor classification, which is still further confused by the persistent failure to view tumors as syntheses of growth phases, which must be described as morphological variations of one and the same tumor instead of distinct tumor entities.

In undertaking the present study, I have entertained many doubts as to the value of the results that my search may yield, and have therefore approached it with "a feeling of contemning no man's opinion, and with a desire to light my own torch at every man's candle." My claims are (1) that primary ovarian cancer arises from epithelial elements which constitute part of the fully formed sex gland and not from hypothetical "embryonal rests"; (2) that tumors in the course of their evolution present different phases of growth which are not entitled to separate classifications; (3) that there is a close relationship between growth and function; and (4) that "tumors may and do assume the function of the organ from which they spring."

The present study embraces the consideration of granulosa cell cancer; papillary adenocarcinoma; and secondary or metastatic cancer of the ovary.

GRANULOSA CELL CANCER OF THE OVARY

In 1855, Rokitansky described for the first time a type of ovarian cancer composed of epithelium closely resembling the granulosa of the follicles and in which folliculoid and ovuloid bodies are present from time to time. Thirty-three years later Acconci published a similar observation. Since 1888 many theories and hypotheses have been evolved about the origin and morphology of this rather rare type of ovarian cancer. The pertinent questions in the study of granulosa cell cancer are: The genetic source; the morphologic significance of the ovuloid and folliculoid bodies; and the interpretation of the different configurations assumed by the granulosa cells.

THE GENETIC SOURCE OF THE GRANULOSA CELLS

The two main theories accepted by most investigators are: the "granulosa strands" of Walthardt and the "granulosa balls" of Robert Meyer. Both these theories are based upon embryological suppositions purporting that parts of the germinal epithelium that dipped into the ovarian substance during the formative period for the formation of follicles, have never reached this structural goal but have remained as embryonal inclusions. Through some biological impulse these structural vestiges of the rete ovarii and the medullary rays have assumed growth properties and produced the granulosa cell tumors.

How far are these embryological theories substantiated by histopathological findings? Most authorities deny the existence or persistence of these embryonic rests in the fully formed and functioning human ovary. Robert Meyer reported one instance only in which he

[1] Read before the Gynecological and Obstetrical Society of Baltimore, February 14, 1930.

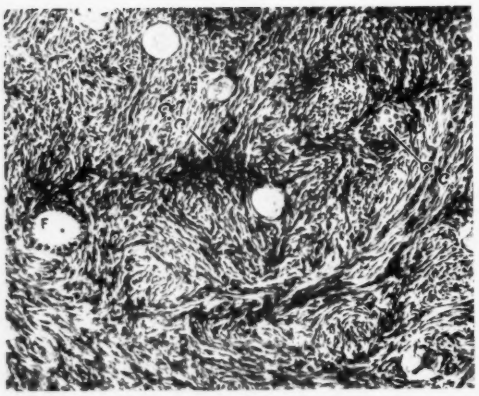


Fig. 1. No. 4804. Granulosa cell cancer of the ovary. A phase in the evolution of the tumor in which the generative and intergenerative elements retain an almost normal proportion. In some of the follicles, *F*, the ovules and the germinal spots are distinctly seen. In some follicles the contents have undergone liquefaction. We also note the earliest beginnings of granulosa cell proliferations, *G.C.* ×40.

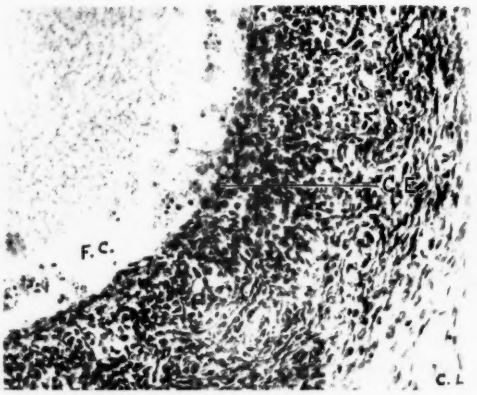


Fig. 2. No. 4804. Granulosa cell cancer of the ovary. A follicle cyst, *F.C.*, showing a proliferation of granulosa epithelium, *G.E.*, extending into the stroma, and into the corpus luteum, *C.L.* ×55.

has found these embryonic remains. In a splendid contribution to the subject of ovarian tumors in 1920, Goodall stated that he had found medullary rays and rete ovarii quite frequently in human ovaries during the fetal and the prepubescent periods only. Goodall's findings agree with those of the majority of investigators. The finding of granulosa cell tumors in women nearing or past the menopause lends additional verification to the claim that the embryological rests could not possibly be the genetic source of these growths.

Can the epithelium of the follicles be the histogenetic source of granulosa cell cancer? Robert Meyer stated in unmistakable terms that no blastomata can arise from follicles, or from any part of them. This postulate cannot be accepted in its totality. We must differentiate between the proliferation of follicles as such and their epithelium. It is an established biological truth that in the human species there is no postnatal proliferation of follicles. The 200,000 follicles with which the human ovary is endowed at birth never increase in number thereafter. In the process of ovulation they undergo elimination, and at the end of the procreative period only traces of their existence are found in the form of scar tissue replacement, called corpora fibrosa and albicantia. The epithelium of the follicles, however, with its unequalled metaplastic prodigiousness, can undergo structural and numerical variations of the widest range postnatally, and give rise to benign and malignant tumors. I claim, therefore, that the granulosa of the follicles can be and is the genetic source of granulosa cell cancer, as will be shown by my histopathological findings further on.

THE MORPHOLOGICAL SIGNIFICANCE OF FOLLICULOID AND OVULOID BODIES IN GRANULOSA CELL CANCER

Von Kahlden, in 1895, considered these morphological phenomena as "a segmentation process of primordial ova in the adult female." Stoeckel, in 1899, considered this type of ovarian cancer "as a formation of ovules and primary follicles in senile ovaries." Amann, in the same year, recorded the folliculoid type of cancer as "a new type of malignant microcystic degeneration of the ovary." Gottschalk, in 1899 and in 1902, coined a new nomenclature for this variety of carcinoma, namely "malignant folliculoma ovarii."

In 1902, Pick stated that the folliculoid tumors described by Gottschalk and by Krompecher were in reality forms of "ovarian struma." Liepmann wrote in 1904: "The

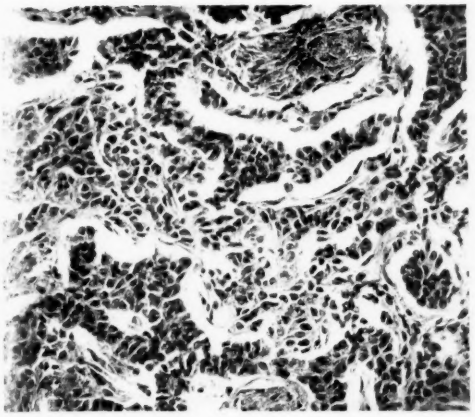


Fig. 3. No. 4804. Granulosa cell cancer of the ovary. A phase in which the granulosa cells are arranged into irregular wavy strands of various thicknesses, or into alveolar and medullary shapes; the rotundity of the epithelial cells is not so pronounced; elongated and polygonal forms are encountered. ×58.

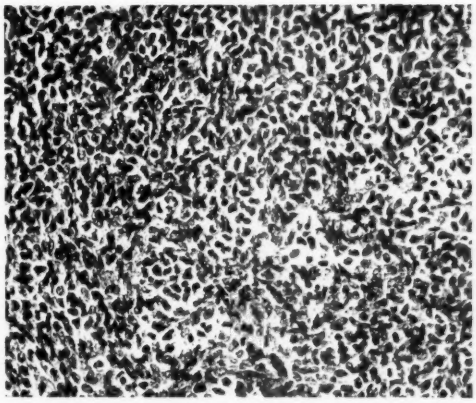


Fig. 4. No. 4804. Granulosa cell cancer of the ovary. A phase in the evolution of the granulosa cell tumor, in which the proliferating granulosa cells form the dominant structural constituent; the stroma is reduced to the lowest proportions, and no traces of the follicles are present. ×58.

ovular formation in ovarian cancer is the result of a regressive metamorphosis, and the designation 'ovular' is baseless, and must be considered as a biologic prodigiousness."

In 1907 and in 1925, Blau stated that his histological investigations led him to believe that "through the proliferation of cells having the morphological potentialities of granulosa epithelium, follicle-like structures are formed with a theca interna. In some follicles there is also an apparent proliferation of lutein cells. These changes resemble the regressive stages of the corpus luteum. In other parts, the proliferation of the cells is more diffuse, and they form nests without the formation of follicles. Blau's description coincides with my own reported in 1923, and his biological concept of the pathology of this tumor is not quite correct as I will show subsequently.

Pfannenstiel's opinion expressed in 1908 varies greatly from that of Blau. He stated: "It is very daring to draw the conclusions from the folliculoid appearances of these structures that we are dealing with follicles. The tumors that have been described as folliculoma have thus far been proved to be partly metastatic carcinoma, partly ovarian struma, or primary ovarian cancer with follicle-like bodies, which has led some authorities to believe that they are dealing with follicular proliferations."

Robert Meyer's hypothesis profferred in 1918 is quite unique; it postulates: "the cells which form the granulosa cell tumors, being derivatives of the germinal epithelium, have a tendency to group themselves around secreted drops extruded by the degenerating cells in a concentric fashion and thus to form round or oval bodies or spherical structures, simulating follicles." He termed this process "liquefaction."

Von Kahlden, Polano, Voigt, v. Werdt, and Krompecher also accepted the theory of degeneration as the causative factor of folliculoid and ovuloid formations in granulosa cell cancer.

Goodall, in 1920, stated that "the granulosa epithelium has the potentiality of forming structures simulating follicles and of producing all the characteristics of true follicles even to the extent of imitating oogenesis."

Sternberg, in his latest contribution to the subject of ovarian tumors, in Halban and Seitz's *Biologie und Pathologie des Weibes*, sets to naught all the theories about the potentialities of the granulosa cells in forming follicles and states: "The resemblance of the follicles and the ovules in granulosa cell cancer to true

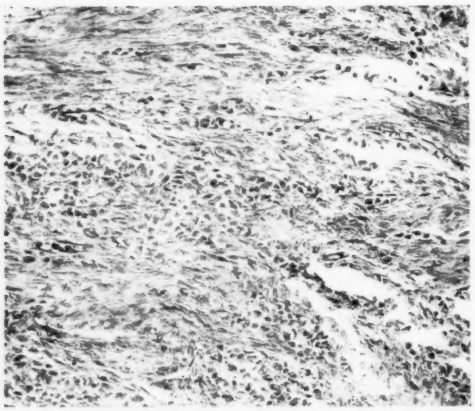


Fig. 5. No. 6388. Granulosa cell cancer of the ovary. Cortical part of the tumor, showing an abundance of stroma, no follicles, the epithelial cells scattered in single rows, or oval and round aggregates. The cells have a round, spindle, or polygonal shape. No signs of necrosis, hyalinization, or lymphocytic infiltration. ×50.

follicles is so slight and insignificant that the designation of these structures with the terms folliculoma is absolutely unjustifiable."

Neither the theory of postnatal proliferation of follicles nor the denial of even a structural resemblance of the folliculoid bodies in granulosa cell cancer to follicles, solve the genetic and morphologic problems of granulosa cell cancer. The proliferation of follicles after birth does not occur in the human female, although it has been observed in the bitch; but that the granulosa cells possess the metaplastic potentialities of the germinal epithelium must be accepted as a scientific working hypothesis, without introducing the far fetched theory of "hyaline degeneration" of Blau, or the "liquefaction" postulate of Robert Meyer. It is my firm conviction that we are much nearer the biological truth if we substitute for the theories of "degeneration" and of "liquefaction" the concept of "reversion to type" as the cause for the formation of the folliculoid and ovuloid bodies in granulosa cell cancer. My own investigations have brought me still closer to the histogenetic and morphological truths of this problem, and I shall show later on that the granulosa proliferation starts from the ovarian follicles, and that the folliculoid and ovuloid bodies in granulosa cell cancer are follicles or the remains of follicles, and not the result of liquefaction or degeneration.

ARE THE DIFFERENT CONFIGURATIONS ASSUMED BY THE GRANULOSA EPITHELIUM DIFFERENT TUMOR ENTITIES OR DIFFERENT PHASES OF ONE AND SAME TUMOR?

An enumeration of the mutiplicity of headings under which granulosa cell cancer has been described will indicate our morphological uncertainty. In 1904, we find three reports on this type of ovarian cancer under three different names: folliculoid cancer of the ovary, by Voigt; pseudo-endothelioma of the ovary, by Polano; ovular formations in ovarian cancer, by Liepmann. In 1907, Brenner described a follicular oophorom; and Inguier a folliculoma ovarii. Werdt, in 1916, described this form of ovarian cancer, as a granulosa cell tumor, thus readopting Rokitansky's original description. Tavildaroff, in 1919, coined a still other term, immature follicular oophoromata, and in 1923 described the same tumor as a "peculiar type of malignant neoplasm of the ovary."

Ulesco Stroganowa, in 1924, wrote on "Folliculoma Ovarii Carcinomatoides." Krompecher, in 1925, described three different morphological entities, "folliculoma," "oophoroma," and "granulosa cell tumors," as component parts of one and the same tumor.

Notwithstanding the correct morphological interpretation of Krompecher, Blau, in 1926, reverted once more to the older teachings and considered the "cylindroid" and the "alveolar" types of ovarian cancer described by Robert Meyer as subgroups of folliculoma ovarii, but refused to classify them with the "oophoromata of Brenner, or with the folliculomata" of v. Kahlden, claiming the latter varieties to be benign neoplasms. Neumann, in 1927, accepted the views of Blau.

My own contribution to the subject of folliculoid cancer, in 1923, did not add a single ray of light to this complicated and confused histogenetic and morphological problem, because my histopathological finding at that time did not differ from those already recorded, and my morphological interpretation was pursued along the accepted methods and

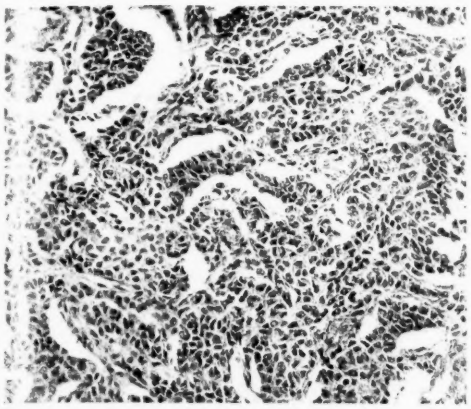


Fig. 6. No. 6388. Granulosa cell cancer of the ovary. A phase of growth in the evolution of the tumor in which the granulosa epithelium is arranged into strands, alveolar and cylindrical masses, forming a pattern closely resembling mohair silk. The cells are characterized by their large, deep staining nuclei, which fill the cell bodies. ×50.

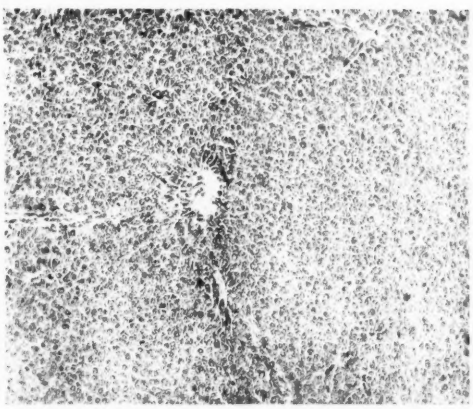


Fig. 7. No. 6388. Granulosa cell cancer of the ovary. A phase in the evolution of the tumor when the granulosa cells form the main constituent of the neoplasm; about the center there is a round space, and ovula formation, or rather the remains of a follicle, surrounded by columnar cells. In the lower right corner there is another follicular space filled with round epithelial cells. ×40.

concepts. Since then I have had the opportunity of studying 4 more cases, which in my opinion have supplied the essential facts necessary to take this controversy out of the realm of hypotheses and conjectures and to place it upon a sound scientific basis.

In the light of biological progress, we must relinquish the older methods of tumor classification, which had its foundation rooted in the local and limited description of what was seen at the time the tumor was examined. This procedure has led to a confusing nomenclature. A tumor must be considered as a composite of growth phases, which are forever changing as long as the neoplasm remains part of the economy. It is true that if a tumor is subjected to an extensive microscopic study several phases may be encountered in one and the same growth; furthermore, the phases noted during the earlier periods of the tumor's evolution may be different in appearance from those which would be found if the tumor were removed at a later date. Conceiving the process of tumor metaplasia in this light, we may hope to reach a clearer conception about the origin and classification of tumors in general and to state definitely that the different configurations noted in granulosa cell cancer are not separate and distinct tumor entities as claimed by many observers but different morphological phases of growth of one and the same tumor type.

HISTOPATHOLOGICAL AND CLINICAL FACTS IN GRANULOSA CELL CANCER

Case 1. Path. No. 4804. R. L., aged 30 years, came under my observation on May 6, 1928, complaining of continuous uterine bleeding since January, 1928, following the termination of her first pregnancy in the seventh month of gestation. Menses began at 15 years, were irregular in type, and occurred every 4, 8, to 12 weeks. Since her marriage 3 years ago the menses have become normal, of 8 days' duration and abundant. Toward the end of the third month of her pregnancy the voice became deep and coarse and has remained so up to the present time. During the fifth month of gestation her face, abdomen, and the lower extremities became covered with a luxuriant growth of hair, which is still present. Throughout the entire pregnancy she vomited daily, and has lost 11 pounds in weight.

Patient is a short, well built individual, who except for her basso-like voice, and the facial and somatic hirsuties, presents all the primary and secondary characteristics of a normal female. The vaginal outlet is normal. There is a moderate bloody uterine discharge. The cervix points backward, the uterus in anterior position is slightly enlarged but otherwise normal. The left adnexa are negative to palpation. The right ovary is of the size and outline of a hen's egg, freely movable, and of a semisolid consistency. No other tumors or nodules are felt.

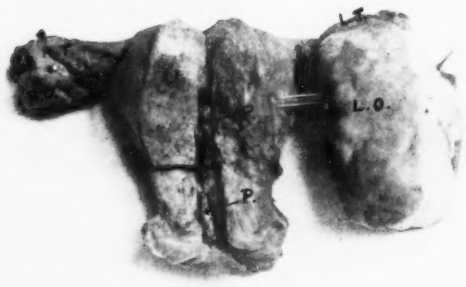


Fig. 8. No. 9055. Granulosa cell cancer of the left ovary. The uterus, *U.*, shows a moderate thickening of the walls; a submucous polyp, *P.*, extends from the fundus to the level of the internal os. The right tube and ovary are normal. The left ovary, *L.O.*, is the seat of a solid globular tumor, the corresponding fallopian tube lies over its upper pole.

Fig. 9. No. 9055. Uterine mucosa in a case of granulo cell cancer. The endometrium shows a marked hyperplas and side by side with cystically dilated glands, bearing low cuboidal epithelium, there are others lined with a hi columnar epithelium which is actively secreting. ×30.

On May 7, 1928, I performed a curettage, right salpingo-oophorectomy, and appendectomy. The recovery was uneventful, and the uterine bleeding ceased on the day following the operation.

Pathological examination showed the following: The right ovary is grayish in color, slightly irregular in outline, of a soft, doughy consistency, with a smooth intact serous covering, and measures 7 by 4 by 5 centimeters. On cross section the tumor presents two distinct structures: a capsule whitish gray in color, very thin except at the lower and inner borders, where it attains the thickness of 1 to 1.5 centimeters, and can be recognized as ovarian tissue. The neoplastic portion is steel gray in color, of a uniform semisolid consistency, and contains an oval, golden yellow body the size of an olive, in its outer and upper pole. Sections from the thicker part of the capsule (Fig. 1) show a typical ovarian stroma harboring many follicles, in some of which ovules are distinctly seen. In others the intrafollicular contents are liquefied and stain pinkish red. In the upper right corner of this section, as well as in the stroma lower down, we see collections of epithelial cells, with dark staining, round and slightly oval nuclei, which occupy the entire cell body and resemble the granulosa cells. About the center of this section these cells seem to spring from the wall of a secondary follicle. In another section we note a follicle cyst (Fig. 2) from the outer wall of which there extends a marked proliferation of granulosa epithelium, which encroaches upon the stroma, displacing but not destroying it, and invades a neighboring corpus luteum. The tumor proper (Fig. 3) contains no vestige of the normal generative elements, the granulosa cells, some of which are round, others ovoid, and still others polygonal, are arranged in irregular winding bizzare strands or whorls with varying amounts of ovarian stroma interspersed. In other parts (Fig. 4) the tumor presents structural phases in which the granulosa epithelium dominat the field. The golden yellow body noted gross proved to be the corpus luteum of the recent pre nancy. In none of the sections did I find evidenc of marked cellular irregularity, mitosis, lymphocyti infiltration, or necrosis.

Had I been content with the examination o the tumor sections presented in Figures 3 and 4 only, I would have had to make a diagnosis of either solid, cylindroid, or of granulosa cell cancer, thus offering a multiplicity of names, without gaining the slightest information as to the possible histogenetic source. Figures 1 and 2, however, representing parts of the tumor in which ovarian tissue could be recognized grossly, have furnished the sought for evidence. It needs no great stretch of our imagination to visualize how the granulosa epithelium which began to proliferate from the walls of the follicles has, in the course of the evolution of the tumor, formed first into thin strands or clumps, then into thicker and wider strands, which have fused with one another and have ultimately almost completely displaced the stroma and the generative elements themselves and have formed a solid tumor composed exclusively of granulosa epithelium. Following this process of reasoning, based upon histopathological facts, we see how erroneous our former methods of tumo

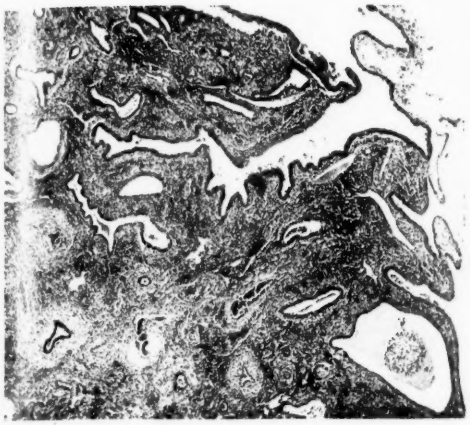


Fig. 10. No. 9055. Uterine polyp in a case of granulosa cell cancer. Note the marked glandular hyperplasia, and the actively secreting epithelium lining the gland lumina. ×35.

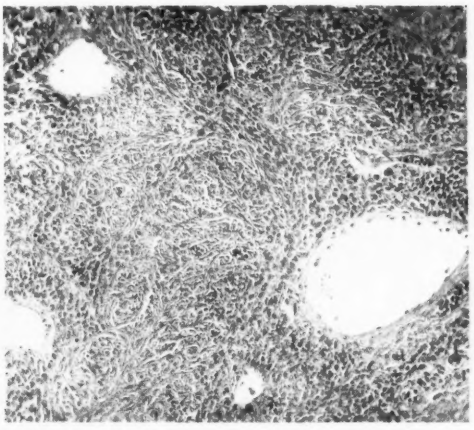


Fig. 11. No. 9055. Granulosa cell cancer of the ovary. (Follicular phase). The granulosa cell character of the proliferating epithelium is distinct; follicle spaces of round and oval outlines, without normal intrafollicular contents are present; the proliferation of the granulosa epithelium proceeds from the follicle spaces into the stroma; the fusion of the epithelial proliferations results in the formation of solid granulosa cell tumors. ×45.

classification was. These different cell groupings in granulosa cell cancer are not different tumors, but different phases of growth of the very same tumor. The clinical facts in this case also shed light upon the problem of the relationship between growth and function. The persistence of the corpus luteum of pregnancy should have inhibited uterine bleeding. It failed in this instance, because the proliferating granulosa epithelium retained not only the structural potentialities of the parent tissue but also its functional proclivities, which overpowered the inhibitory forces and stimulated the endometrium, hence the persistent bleeding as long as the granulosa cell tumor formed part of the economy.

Case 2. Path. Nos. 6388 and 9839. P. S., aged 36 years, came under my care on October 14, 1915, complaining of a progressive enlargement of the abdomen, which has become very pronounced within the past 3 weeks. Menses began at 17 years, were four weekly in type, painless, and moderate in amount. For the past 4 years hypomenorrhœa has been noted, the intervals varying from 6 to 8, and 11 weeks. The last period occurred 1 week ago. She has been married 15 years, has given birth to three full term normal children, the last one 10 years ago. Her relative sterility is not volitional. Physical examination discloses a large, tense abdomen containing a huge cystic tumor. The uterus is of a normal size and outline, and lies in front of the lower pole of a huge ovarian cyst.

October 18, 1915, I performed a right salpingo-oophorectomy, preceded by the aspiration of 7,200 cubic centimeters of a serosanguineous fluid from the ovarian cyst. Some of the cyst contents escaped into the peritoneal cavity. The uterus and the left adnexa looked normal. The recovery was smooth and the patient left the hospital on the twelfth day, feeling well.

Pathological examination reveals the following: A huge ovarian cyst, with a smooth glistening surface, the walls of which are alternatingly thick and thin. The contents are serosanguineous, and the inner surface has a soft velvety irregular appearance. The serosa is covered with a low cuboidal epithelium which is wanting in some parts. Right under the serosa is a layer of ovarian stroma of varying thickness (Fig. 5) infiltrated with round and oval epithelial cells with large, dark staining nuclei, filling the cell bodies. In the more mesial sections of the tumor we find the parenchyma cells arranged in two forms: a mohair silk pattern (Fig. 6) and a solid mass of epithelium (Fig. 7), which shows in various parts round or ovoid spaces, with a homogeneous pink liquefied mass in the interior. While the cells maintain throughout a fairly uniform rotundity, those bordering on the ovuloid spaces assume a columnar shape. Mitosis, lymphocytic infiltration, and necrosis are wanting.

On February 11, 1917, the patient reported that since her operation 2 years ago, the menses have been normal and that the last period occurred on June 9, 1916. An examination disclosed a gestation of 8 months. On March 17, 1917, I delivered her of

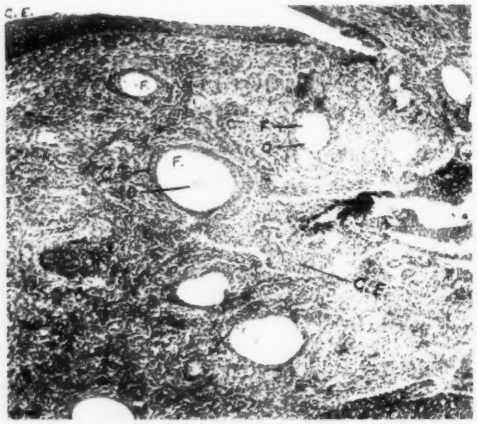


Fig. 12. No. 2999. Granulosa cell cancer of the ovary. An early phase in the development and growth of a granulosa cell tumor; the follicles, *F.*, are easily identified. Some of them still contain ovules, *O.*, and germinal spots. Note the invasion of the stroma by the proliferating granulosa epithelium, *G.E.*, which proceeds from the follicle walls. ×35.

Fig. 13. No. 2999. Granulosa cell cancer of the ovary. The characteristic granulosa epithelium, *G.E.*, with its rotundity and uniformity and its round deep staining nuclei, forms the main structural component of the tumor parenchyma. The continuity of the epithelial mass is broken here and there by round or oval spaces, the remnants of follicles, *F.*, or by islands of ovarian stroma, *O.S.*, which have not been displaced as yet. ×30.

a full term normal child. The delivery and the puerperium were normal.

On June 8, 1919, the patient stated that since her last delivery 2½ years ago, she had menstruated but twice, the last time on April 26, 1918, and that since then she has had trouble with flashes, dizziness, and perspiration. Pelvic examination revealed a retroverted uterus and a cystic enlargement of the left ovary to the size of an adult fist. The rest of the pelvis and the abdomen were apparently free. Bearing in mind the pathological findings in 1919 (reported at that time by the pathologist as adenocarcinoma), I urged the patient to be again operated upon. My advice was not taken.

On September 21, 1919, she returned complaining of progressive abdominal enlargement. On examination I found free fluid in the peritoneal cavity, and an increase in the size of the left ovary, which by this time was fixed in position. I reoperated on September 27, 1919, but the condition was beyond surgical relief. A specimen was removed for microscopic study, and the morphological findings were identical with those found in 1915, with the exception that at this time I have found signs of beginning necrosis. Nine months later the patient finally succumbed.

Clinically this case presents the following points of interest: (a) The comparative benignancy of this type of ovarian cancer; (b) the successive involvement of the ovaries; and (3) the complete restoration of normal menstruation and fecundity after the removal of the diseased ovary. Histopathologically this case furnishes the following facts: From the morphological characteristics of the epithelial cells forming the parenchyma of the tumors, this neoplasm must be classified under the group of granulosa cell cancer and not as an adenocarcinoma as reported by the pathologist in 1915. While I did not find in this specimen histogenetic evidence, I did find arrangements and groupings of the epithelial cells similar to those observed in the preceding case—thus our modern concept of tumor evolution was substantiated. The histogenesis in this case was established on the facts brought out in the preceding study, although only faint indications of follicle-like structures were seen in the solid portions of the tumor.

Case 3. Path. No. 9055. J. A., aged 54 years. VI-para. The youngest child is 24 years old. The menopause began 7 years ago. On November 20, 1928, patient began to bleed vaginally, and the hæmorrhages have continued for the past 3 weeks.

Physical examination reveals a slightly relaxed vaginal outlet; cervix normal to sight and palpation; the uterus somewhat larger than normal for this period of life, slightly irregular in outline, and firm in consistency; the left ovary the seat of a globular

hard tumor the size of an adult fist; and the right adnexa apparently normal.

On November 28, 1928, I performed an abdominal panhysterectomy and a bilateral salpingo-oophorectomy. The postoperative recovery was uneventful.

Pathological examination discloses the following: The specimen (Fig. 8) consists of the uterus and its adnexa. The uterus measures 8.7 by 6 by 4.6 centimeters, it contains a few tiny interstitial fibroids, the walls are 5 centimeters thick, and a thin polyp extends from the fundus to the level of the internal os. The right adnexa are apparently normal. The left ovary, of solid consistency, measures 8.1 by 4.6 by 4.3 centimeters. Its outer surface is nodular and yellowish in color. The covering serosa is smooth and glistering. On cross section a distinct capsule can be noted, varying in thickness from 0.5 to 1 centimeter, and recognizable as ovarian tissue.

The endometrium (Fig. 9) is markedly hyperplastic, presenting besides a cystic dilatation, also an active secretion in some of the glands as indicated by the height of the columnar epithelium, and by the mucous and bloody contents in their lumina. The glands in the uterine polyp (Fig. 10) show a still more pronounced activity than that noted in the endometrium proper. Sections from the cortical portion of the left ovary show a rim of ovarian tissue, of different thicknesses, covered with a low cuboidal epithelium, harboring corpora albicantia, and in its mesial parts an invasion with granulosa cell cancer. Sections from the more centrally located portion of the tumor (Fig. 11) show an invasion of the stroma with granulosa-like epithelium, which proliferates from the periphery of round and ovular spaces of various dimensions. As these epithelial masses join with each other, the intervening stroma disappears, and solid clumps of granulosa cells form. The epithelial cells bordering on the ovuloid or folliculoid spaces occasionally take on a columnar form. The lumina of these spaces may or may not be filled with a pinkish staining homogeneous mass. Other arrangements and groupings of the granulosa cell cancer are found in the same tumor, either as branching strands, identical with the descriptions given by v. Werdt; and in other parts in the form of long strands made up of single rows of cells.

The histopathological facts in this case point to the granulosa surrounding the folliculoid and ovuloid spaces as the source of the tumor growth. I retain the term folliculoid and ovuloid cancer in this instance because the spaces found within the granulosa cell masses do not contain distinctly recognizable ovules; otherwise I would have called this phase of granulosa cell cancer as the follicular stage or the early stage in the development of this tumor. From Figure 11 we can also learn that these round and oval spaces are not morphological sequences to a unique form of "liquefaction" as claimed by Robert Meyer, but definite structures in which the only type of liquefaction found is within their lumina, which is also characteristic of normal ovarian follicles. The further histopathological phenomena presented by this tumor are identical with those already described.

This case also demonstrates once again the influence of growth on function. If my histogenetic claim is correct, that the epithelium forming the granulosa cell cancer is derived from the follicles, then the biological function inherent in these cells ought to manifest itself clinically in a renewed or an increased ovarian function, which would express itself through the uterine mucosa. In this case we found an hyperplasia of the endometrium and an onset of uterine bleeding long after the menopause had been established. The hyperactivity or renewed activity in the uterine glands was noted not only in the polyp, which is in itself an expression of growth stimulation, but in the endometrium as well. What stronger proof need be offered to show that there exists a close relationship between growth and function, between biology and pathology?

CASE 4. Path. No. 2999. M. F., aged 36 years, came under my care on May 7, 1925, complaining of a rapid increase in the size of her abdomen within the past 5 weeks. Menses began at 13 years, were four weekly in type, and painless and moderate in amount. The last period occurred 14 months ago. She has given birth to four full term normal children, the last one 5 months ago.

Physical examination reveals the abdomen enlarged and bulging due to the presence of free fluid; the pendulous part of the abdominal wall œdematous. No masses are palpable. On vaginal examination a tumor the size of a goose egg is felt in the left iliac fossa. The uterus and the right adnexa are apparently normal. Douglas's cul-de-sac is bulging as a result of the free fluid in the peritoneal cavity, but no nodules are felt.

On May 8, 1925, I performed an abdominal panhysterectomy, bilateral salpingo-oophorectomy, and appendectomy. Besides the free fluid there were no evidences of any metastases.

Pathological findings are as follows: The uterus and the right adnexa are normal. The left ovary is the seat of an oval shaped cystic tumor, measuring 9.5 by 6 by 5.5 centimeters. Its outer surface is smooth and shiny, the color grayish yellow, and the walls rather thick. On cross section the cyst wall shows two distinct layers: an outer, denser, of grayish tint; and an inner, softer one of a yellowish color and wavy outline. Sections from the outer layer

show a great deal of ovarian tissue that is œdematous and engorged. Of the generative elements, corpora fibrosa and albicantia predominate in some parts, while in others a considerable number of follicles is present (Fig. 12). These follicles show a marked proliferation of their granulosa which extends outward into the stroma. Some of the follicles are moderately cystic, contain ovules, and in some instances the germinal spots are still discernible. The tumor proper (Fig. 13) is composed of dense areas of round, epithelial cells with dark staining nuclei, of striking uniformity, showing no mitosis or degeneration. The continuity of the epithelial inundation is broken here and there by oval or round spaces, the remains of follicles; or by islands of ovarian stroma which has not as yet been displaced.

In June, 1925, this patient received a postoperative course of deep X-ray treatment. Repeated vagino-abdominal examinations made every 4 weeks up to January, 1926, proved to be negative. During this period of observation the patient has gained in weight and has felt well, except for the vasomotor disturbances induced by the surgical menopause. Her breasts continued to secrete milk freely for 8 months after the operation. Since January, 1927, I have lost track of this patient. Inquiries failed to show her death record so I assume she is still living.

The histopathological criteria found in this case leave no more room to doubt the histogenesis of granulosa cell cancer. Up until now I have followed the precautions taken by other authorities and have called the oval and the round spaces found in granulosa cell cancer, folliculoid or ovuloid formations; because I failed to find absolute proof of the identity of these structures to follicles. With the finding of unmistakable ovules in these spaces and with the demonstration of the granulosa proliferations from their circumference, the final histogenetic proof is established. We can therefore state now with absolute conviction that the granulosa epithelium forming the parenchyma of this type of ovarian cancer takes its origin from the follicles and not from hypothetical embryonal rests, and that the round or oval spaces present, even when devoid of normal or recognizable intrafollicular contents, are not the result of a process of "liquefaction" or of "degeneration," not even of a possible "reversion to type" by the granulosa epithelium, but the remains of real follicles.

SUMMARY AND CONCLUSIONS

1. The morphological truth enunciated by Rokitansky 75 years ago that the epithelium forming this unique type of ovarian cancer is of the granulosa variety, is fully substantiated.

2. The histogenetic hypothesis that the granulosa hyperplasia starts from embryonal rests, the rete ovarii, and the medullary rays, must be renounced; because the morphological facts brought forth in this study show that the structural origin is the granulosa of the already formed follicles and because the presence of these assumed embryonic rests do not exist in the adult human ovary.

3. The presence of easily recognizable ovules in the round and oval spaces in granulosa cell cancer establishes their morphological significance and makes the terms "folliculoid" and "ovuloid" hitherto employed, superfluous. The fact that in many of these spaces no trace of ovules is found does not warrant such terms as "liquefaction," "regression," or even "reversion to type."

4. I agree fully with those authorities who contend the impossibility of postnatal follicular proliferation, but disagree with those who deny that the follicle epithelium possesses metaplastic and hyperplastic potentialities. For if other types of epithelium in their function as secreting or protective structures may from time to time exceed their normal growth limitations and form benign or malignant tumors, why cannot the granulosa epithelium with its rich proliferative endowments become the seat of similar morphological disturbances?

5. The classification of granulosa cell tumors into cylindroid, folliculoid, solid, and other types, is only confusing. They are not different tumor entities but different growth phases in the evolution of the same tumor. In describing the morphology we ought to indicate these phases, which would simplify tumor nomenclature.

6. The outstanding morphological differences between the granulosa cell cancer and other forms of carcinoma are: (a) The uniformity of the proliferating epithelium, particularly during the early stages of the neoplastic development; (b) the absence of mitosis, with rare exceptions; (c) the absence of infiltrative and destructive tendencies; and (d) the spreading of the tumor by continuity and extension and not by way of the lymphatic or blood streams.

7. As confirmative evidence of the histogenetic truth of granulosa cell cancer is the power of the proliferating epithelium to augment the function of the still active endometrium, or to reawaken its functions after it has been dormant for some time, by virtue of an increase of the ovarian hormone content in the blood. This clinical observation made by me, was also noted by H. O. Neumann, Robert Meyer, Mullersheim, Walthard, and O. Frankl.

PAPILLARY CARCINOMA AND PAPILLARY ADENOCARCINOMA OF THE OVARY

The theoretical dissensions about the origin and classification of papillary carcinoma and papillary adenocarcinoma of the ovary are not less numerous and contradictory than those which prevail in the chapters on granulosa cell cancer. Thirty years ago Orth propounded the following questions: (1) Do the simple and the papillary cysts, lined with ciliated or non-ciliated epithelium, have the same origin? (2) Do they start from the germinal epithelium (i.e., the surface epithelium), or from follicle epithelium? (3) Are embryonic rests of the ovary, or of the wolffian body, to be considered as the genetic sources? To these three pertinent questions I would add a fourth: Are all surface papillomata continuations of the intracystic growths?

The literature antedating Orth's publication and that which has appeared since then represents a continuous academic dispute. Which are the kernels of scientific truth in this welter of recorded investigation?

Since Klebs and Waldeyer have proved that ovarian cysts do not form as a result of colloid degeneration of the ovarian stroma but that they are the products of epithelial metaplasia, numerous studies have been undertaken to ascertain which of the epithelial depots in the ovary is the genetic soil—the germinal epithelium, the assumed embryonal rests, or the follicle epithelium. Waldeyer and Nagel were among the first to deny the embryonal rest theory, because as already stated, these structures disappear from the ovary soon after its differentiation into the sex gland. Waldeyer believed that through the invagination of the surface epithelium neoplasms may develop within the ovary. Amann, Frommel, Klebs, v. Kahlden, Nagel, Steffeck, Stratz, Sampson, and many others are firmly convinced of this genetic possibility. And while many have promulgated the theory of inflammation as a predisposing factor to this invagination of the surface epithelium, Sampson in his masterly contributions has proved this supposition to be an uncontrovertible fact.

As early as 1879 Marchand stated that all papillary cysts of the ovary arise from follicles or from structures simulating follicles, which in turn were formed from the surface epithelium, covering the lateral parts of the ovary. Among the recent observers who have espoused Marchand's postulate are Steffeck and Stratz; all others refute it.

The contemporary dean of gynæcic pathology, Robert Meyer, stated in unequivocal terms "no cystomata can arise from follicles." Goodall wrote: "To my mind there is not one case in the literature of a graafian follicle that is supposed to show developing papillomata, that will stand the test of scientific criticism."

According to these eminent investigators, the follicle epithelium must be discarded as a possible genetic source of papillary growths. A still more divergent and extraordinary histogenetic theory of epithelial tumors in the ovary is that of Walthardt. He wrote: "The squamous, the ciliary, and the goblet epithelium forming the corresponding ovarian neoplasms, arise neither from the surface epithelium or its antecedents, nor from the follicle epithelium and its precursors, nor from the embryonal rests of the primordial kidney, but from congenital anlagen of squamous, of ciliary, and of beaker cells." He stated further: "the development of proliferating ciliary, squamous, or beaker cell adenomata is conditioned not alone upon the corresponding type of misplaced epithelial rests, but also upon their accompanying stroma, derived from the differentiated ovarian connective tissue. Without its stroma these different types of epithelium would degenerate, and the spaces formed as a result of this regressive metamorphosis would have been filled with normal ovarian stroma."

Walthardt's dictum that each type of epithelial tumor in the ovary arises from a corresponding congenital anlage, surpasses all morphologic speculations and is contrary to the accepted laws and observations formulated and recorded by Marchand, Malasses, de Sinety, Flaischlein, Fischel, Lauche, and many other recognized authorities. Walthardt's theory must be considered as the phantasy of a great but lone observer.

I am certain that all these contradictory views would have been reconciled long ago, and Orth's questions regarding the histogenesis and classification of benign and malignant papillary tumors of the ovary would have been answered by this time, more satisfactorily than has been done up to the present, if those who labored so assiduously in this field, would have heeded his admonition, that "we cannot draw histogenetic conclusions from fully formed tumors." I have demonstrated the soundness of this warning in my study of granulosa cell cancer and expect to prove it once more in the case of papillary tumors of the ovary.

HISTOPATHOLOGICAL AND CLINICAL FACTS IN PAPILLARY CARCINOMA AND PAPILLARY ADENOCARCINOMA OF THE OVARY

CASE 1. Path. No. 3533. L. L., aged 19 years, married 15 months, nullipara. Menses began at the age of 12 years, were three weekly in type of 2 to 3 days' duration, moderate in amount, and painful. The last period occurred on November 7, 1925. Her chief complaints on November 25, 1925, were backache, for the past 2 years, worse during menstruation, pain in the lower abdomen, and sterility.

Physical examination discloses a well nourished normal female. The abdomen is enlarged by a cystic tumor which extends from the xiphoid cartilage down into the pelvis. The outlines of the tumor are irregular, and its consistency varies from softness to semisolidity. The vaginal outlet is normal. The uterus is of normal dimensions and is held forward by the lower pole of the tumor. Another cystic tumor the size of a grape fruit, which is not palpable abdominally, occupies the right iliac fossa.

On November 28, 1925, I performed a supracervical hysterectomy and a bilateral salpingo-oophorectomy. There were no metastases or free fluid in the peritoneal cavity. The postoperative recovery was uneventful.

Pathological examination shows the following: The uterus is somewhat smaller than normal at this age, otherwise negative. Both ovaries are converted into cystic tumors, pearl-gray in color, the outer surfaces of which are studded with small papillary growths. On cross section they present a honeycombed appearance, formed by the walls of the daughter cysts, which in turn bear papillæ on the interior. The more solid portions of the tumors consist of a yellowish gelatinous substance which fills the cyst cavities. The fallopian tubes lie stretched across the anterior surface of each ovary. The neoplasm is a papillary adenocarcinoma (Fig. 14, No. 3973), in which the papillary type predominates. The epithelium covering the papillæ or lining the adenomatous spaces is for the most part columnar, non-ciliated in type. Here and there we note that next to distinctly malignant cells are low cuboidal, microscopically benign cells. Sections from areas of the cyst wall, with surface and interior papillæ opposite each other at almost the same spot (Fig. 15, No. 3973), showed no structural continuity between the two. The intervening ovarian stroma forming the cyst wall is not invaded by the malignant epithelial metaplasia, and the lymphatics as well as the blood vessels are also free from metastatic involvement. We may also note an abrupt transition of the normal epithelium on the surface of the ovary into a malignant form. The serosa covering the fallopian tubes (Fig. 16, No. 3533) is thrown into folds which carry along with them connective tissue stalks forming papillæ and adenomatous spaces and showing, in the covering epithelium, also a sudden transition from a normal to a malignant state.

The histopathological findings presented in this and other cases are: (a) a sudden transition from a microscopically normal epithelium to a distinctly malignant form; (b) the structural independence between the surface and the interior papillæ; (c) the evident genetic source of the surface epithelium and lack of evidence regarding the source of the interior epithelium (for we do not know as yet how this epithelium has found its way into the depths of the ovary); and (d) the fact that the epithelium covering the fallopian tubes also manifests a papillary formation simulating that noted in the ovaries. This last finding has led to the conclusion that these epithelial centers must have had a common genetic soil and that they are both capable of responding to the same growth stimulant.

CASE 2. Path. No. 3246. R. B., age 65, X-para. The youngest child is 20 years old. On February 16, 1928, patient complained of heaviness in the lower abdomen, backache, and frequent urination.

Physical examination discloses moderate relaxation of the vaginal outlet. The cervix is short, is pressed upward against the symphysis pubis by the lower pole of a cystic tumor which extends upward

from the pelvis to a point 2 inches above the umbilicus. The left ovary is palpable and is apparently normal.

On February 17, 1928, I performed a supracervical hysterectomy and a bilateral salpingo-oophorectomy. No ascites or metastases were present. The postoperative recovery was uneventful.

Pathological findings were as follows: The specimen consists of a small atrophic uterus lying between two ovarian tumors. The right neoplasm is the size of a fetal head, grayish in color, and is alternately thick and thin in consistency. The outer surface is smooth except at points where it was adherent to adjacent structures. The left ovary is twice the normal size and contains a few microcysts.

The right ovary is the seat of a papillary adenocarcinoma, which differs in no way from the classical type. The left ovary (Fig. 17) is the seat of an apparently benign adenoma. Some of the gland spaces show the beginnings of papillary formations. The columnar epithelium in some of the glands shows some unrest, perhaps early malignant changes. We also note a few primary follicles in the cortical portion of the ovary. In another section we find a large irregular cystic cavity (Fig. 18) with a tuft of papillæ projecting into it. The lining epithelium of this space differs from a very low cuboidal, to a distinct columnar type, which dips into the underlying stroma at various points of the circumference. There are also areas (Fig. 19) in which a structural continuity between the surface epithelium and the adenomatous spaces is seen. Note how an epithelial fusion takes place between these two epithelial depots, and at the same time the independent formations of surface and interior papillæ.

On June 20, 1928, this patient returned complaining of repeated attacks of abdominal cramps. An examination disclosed a tumor mass the size of a fist in the posterior fornix. The previous pathological findings have influenced my clinical judgment, and I have diagnosed the case as a metastatic intrapelvic tumor, although no other masses or free fluid were present. Deep X-ray therapy was instituted at once. A re-examination on October 18, 1928, showed that the tumor mass felt originally in the posterior fornix was now much higher and more freely movable. My diagnosis of metastases from the ovarian carcinoma was now abandoned and I re-operated on October 22, 1928, and instead of finding an intraperitoneal cancer mass, I found an adenocarcinoma of the sigmoid flexure (Fig. 20). The peritoneal cavity was free from metastases. A resection of the affected intestine was performed. The patient developed a fæcal fistula, and the long stay in bed debilitated her already exhausted state of health, and she succumbed about 6 weeks later.

The histopathological findings and the clinical data in this case throw valuable light on the problems of the histogenesis of papillary ovarian tumors, upon epithelial metaplasia, and upon the multicentric origin of new-growths. The morphological facts in Figure 19 show how the surface epithelium has found its way into the ovarian interior, thus paving the way for papillary and adenomatous formations. In Figure 18 we note the growth of papillæ into a cystic space which must have been a cystic follicle, although it can no longer be identified as such. This suggests another genetic source for papillary growths, namely, the follicle epithelium. But I shall not force this genetic issue until more positive histopathological facts can be adduced.

Both ovaries are affected with papillary adenomatous metaplasias, malignant in the right and benign in the left. This difference in the nature of these fundamentally identical tumors must be explained on the ground that additional histobiological and biochemical factors must have arisen in the right gland, which have brought about this change. And it is my opinion that in time the same malignant condition would have arisen in the left ovary as well. This statement is not an histopathological prophecy based on assumption, but a well founded fact supported by repeated clinical observations. Many of us have had to remove the second ovary months or years after having removed the first one for malignancy, diagnosed at the time of the operation or subsequently, although at the time of the primary operation the ovary not removed looked and felt normal.

This case presents also data bearing upon the autochthonous development of the ovarian and the sigmoid carcinomata. The distinctly different types of cancer in each instance, excludes in a large measure their common origin. If the ovarian cancer were secondary in nature, its spread from the intestine could have taken place only via the lymphatic or blood streams, or by continuity and contiguity. Microscopically, I did not find any invasion of either of these carriers. Clinically not the slightest evidences of adhesions between the pelvic organs and the sigmoid were present at the time of the first operation. At the second operation the peritoneal cavity showed again freedom from metastases and the tumor bearing portion of the sigmoid was freely movable, and the muscularis of the intestinal wall also failed to show carcinomatous

invasion. In view of these facts, we can state that this patient's immunity to cancer had been lowered, and she was, therefore, apt to develop carcinomata in more than one place, independent of lymphatic or blood vessel transportation or of continuity or contiguity.

CASE 3. Path. No. 10172. E. G., aged 37 years. Menses began at 14 years, were of the 25 day type, painless up to 3 years ago, and profuse most of the time. The last period occurred on January 23, 1929. Since her childhood she has been complaining of indefinite pains in the right lower quadrant of the abdomen. For the past few years she is conscious of a movable abdominal mass.

Physical examination discloses a well nourished individual, the heart and lungs are normal. The abdomen contains a hard irregular freely movable tumor. Recto-abdominal palpation suggests the diagnosis of multiple uterine fibroids.

On February 5, 1929, I removed five interstitial fibroids, the right uterine adnexa, and the appendix. The postoperative course was uneventful.

The pathological findings were as follows: The enucleated fibroids vary in size from a grape fruit to a hen's egg. The right ovary is slightly enlarged, bluish in color, cystic in consistency, and covered with a smooth glistening serosa. The cyst wall consists of a broad strip of ovarian stroma, somewhat œdematous, moderately infiltrated with lymphocytes (Fig. 21), covered with a layer of cuboidal and partly columnar epithelium, showing distinct carcinomatous metaplasia, which dips into the underlying stroma and invades it from without. The tumor proper consists of the usual adenocarcinomatous growth. The mucosa of the right fallopian tube (Fig. 22) also shows a marked epithelial unrest. In some spots the basement membrane is broken through, and next to apparently normal single layered epithelial cells, we see irregular, multilayered, columnar epithelium with mitotic figures. The underlying stroma is mildly infiltrated with lymphocytes. The lymphatics and blood vessels of the tubal wall are free from cancerous invasion.

On February 24, 1929, I removed the uterus and the left adnexa. No evidences of metastases were present. The recovery from the second operation was also smooth and uneventful. Deep X-ray therapy was instituted on the fifteenth day after the second operation. The patient is well, except for the vasomotor disturbances which are treated endocrinologically.

Pathological findings were as follows: The uterus is normal in appearance except for the scars on its outer surface caused by the myomectomies. The walls are thickened and measure 6.5 centimeters. The endometrium shows marked hyperplasia for a distance of 2.5 centimeters on the lower part of the left wall. The left adnexa appear to be normal. On cross section the left ovary shows a recent corpus luteum of menstruation, otherwise normal.

The corpus luteum is in the stage of vascularization, and of the other generative elements we find a few corpora fibrosa, primary and secondary follicles. At the meeting point of the cortical and medullary portions of the ovary a few areas are present showing typical granulosa cell cancer (Fig. 23) in the form of solid masses infiltrating and displacing the stroma, or spreading from the periphery of cystic follicles into the stroma. The mucosa of the left tube also showed some cellular unrest but not as pronounced as in the right. The area of endometrial hyperplasia noted macroscopically (Fig. 24) shows a distinct adenocarcinomatous hyperplasia and metaplasia, next to which lies an apparently normal endometrium except for a mild degree of cystic dilatation of some of the glands.

This case illustrates once again the fact of multicentric autochthonous development of carcinoma in the generative tract. In the right ovary we have found a distinct type of adenocarcinoma, with papillary formations in some areas. In the left ovary is a typical granulosa cell carcinoma. The mucosæ of the uterus and the left fallopian tube have also participated in the cancerous metaplasia and so did the serosa of the ovary. These findings speak for a primary cancer of the generative tract, affecting its lining, covering, and parenchymatous epithelium, all of which emanate from a common genetic soil. The morphological variations noted in the affected epithelium in the various subdivisions of the generative tract are due undoubtedly to the differentiations which the original cœlomic epithelium has undergone in the different sections of the tract in the process of organic formation, as well as to local conditions which greatly influence morphology.

CASE 4. Path. No. 3785. J. F., aged 33 years, III-para. The youngest child is 3 years old. Menses began at 16 years, were of the 28 day type, of 4 to 5 days' duration, moderate in amount and painless. The last period occurred on January 28, 1928. Her chief complaint on February 15, 1928, was pain in the right side of the abdomen.

Physical examination disclosed tenderness over the gall-bladder region, and a multilocular cyst of the left ovary as large as a grape fruit.

On February 24, 1928, I performed a supracervical hysterectomy, a bilateral salpingo-oophorectomy, appendectomy, and cholecystectomy. The patient left the hospital on the fourteenth day after the operation, feeling well.

The pathological examination showed the following: The gall bladder measures 15 by 8 centimeters, the walls are thickened, and it is filled to capacity

with faceted stones of various sizes. The appendix is normal. The left ovary is the seat of a cystic tumor the size of a grape fruit, covered with many papillary growths. The right ovary is normal in size, contains a few follicle cysts, and shows tiny papillæ on its outer surface.

The neoplasm in the left ovary is a typical papillary adenocarcinoma, with hardly a trace of recognizable ovarian tissue. In some of the sections normal looking epithelium lies next to the definitely cancerous tissue, a phenomenon which I have repeatedly observed. Sections from the right ovary (Fig. 25) show a great deal of tissue which can be identified as ovarian in structure, many cystic follicles lined with several layers of granulosa epithelium and surrounded by a well developed theca externa, which is readily differentiated from the surrounding ovarian stroma by its lighter color and looser texture. Some of the cystic follicles show a papillary formation (Fig. 26) which can be traced from their earliest stages of development, indicated by tiny folds of the lining of the follicles to fully formed tree-like growths. The mucosa of the left fallopian tube also shows a precancerous stage and the serosa of the left salpinx shows papillary formations of a definite character. The same phenomenon is also observed in a cystic subperitoneal cavity of the fallopian tube.

The pertinent histopathological facts in this case are: (a) the presence of papillæ in a cystic follicle; (b) the simultaneous participation of different epithelial depots in the papillary metaplasia, besides the ovary, namely, the serosa of the fallopian tubes, and the endosalpingium; (c) the structural independence of the surface from the interior papillæ; and (d) the presence of normal epithelium close to distinctly malignant cells.

SUMMARY AND CONCLUSIONS

1. Contrary to Robert Meyer's teachings that neither follicles nor any part of them can be a genetic source of tumor formation, I hold with Marchand that they can and do give rise to granulosa cell cancer and to papillary growths of a benign and a malignant character. I believe that this is the first study in which Marchand's claim is verified and substantiated with histopathological facts.

2. The traditional teachings that the surface papillæ are continuations of intracystic growths could not be supported by my findings, which show their respective independent development from the outer and the inner layers of epithelium covering and lining the cyst walls.

3. The participation of the covering and the lining epithelium of the fallopian tubes and the uterus in the benign and malignant papillary and papillary adenomatous formations in the ovary, demonstrated the common genetic soil of all these epithelial centers, their equally inherited biological potentialities, which respond to the same growth promoting stimuli, thus undergoing an almost similar morphological change.

4. The finding of benign looking epithelial cells adjacent to cells which are definitely malignant, in papillary adenocarcinomata, indicates first, that the cancer cells are evolved from previously (microscopically) normal ones; and, second, that this seemingly sudden transition must in reality be a gradual one, although we cannot detect with the ordinary means employed, the finer intermediary stages that lead up to the morphological identification of malignancy.

5. The autochthonous, multicentric, and simultaneous occurrence of different types of primary cancer in the generative tract, as exemplified in this study, presupposes a multiplicity of cancer hormones acting concurrently. Some hormones are capable of arousing both the epithelium and its underlying stroma to form papillæ and papillary adenomata, others activate the parenchyma only and form granulosa cell cancers.

METASTATIC CANCER OF THE OVARY

We have been taught for many years that cancer may metastasize to the ovary via one of the following routes: (a) by continuity; (b) by contiguity; (c) by implantation; and (d) by way of the lymph and blood vessels. Ribbert, Offergeld, Schottlander, and others have drawn very fine distinctions between the processes of continuity and contiguity, claiming that in the former process adhesions form between the adjacent organs and that along these bridges of tissue the cancer cells are transported; while in the latter event the migration of the malignant cells proceeds without the intervention of tissue continuity. The last conjecture is hardly believable, for in my experience I have found that the apparent "macroscopic contiguity" has proved to be a "microscopic continuity." I cannot imagine

cancer cells traversing through space like the pollen of flowers and becoming implanted by this process in remote lying tissues and organs. It is my opinion that the concept "contiguity" may be dismissed from the subject of cancer pathology without sustaining a scientific loss.

The theory of "implantation" postulates that particles of cancer tissue may separate themselves from their primary base, such as the gastro-intestinal tract, and be carried to the surface of the ovary by the peristaltic waves in the abdomen, and become implanted, in what Schauta termed, the physiological defects caused by the process of ovulation. My own clinical experience does not support the theory of "implantation," for in outspoken cases of metastatic ovarian carcinoma secondary to gastric and gall-bladder malignancy, I could find cancer particle not on the surface of the ovaries, but in the lymphatics of the interior.

The soundest of all theories formulated about the manner and method of cancer metastasization is the one of the lymph and blood vessel routes, and this theory is easily and frequently verified. In fact, some authorities admit of no other possibility. For a time pathologists could not explain how cancer of the upper abdomen could metastasize to the ovaries via the lymph and blood vessel streams, for in such an event a reversion or back flow in the circulation must occur. Pfannenstiel and Schottlander admitted the occurrence of this vicious cycle and have termed it "retrograde transportation," which is now universally accepted.

Kehrer and Amann described the mechanism of "retrograde transportation" as follows: "The lymphatics of the stomach empty into the retrogastric lymph glands, from here the lymph is carried to the superior lumbar glands, which also receive the lymph channels from the ovaries. It is from the lumbar glands that a retrograde flow to the ovaries takes place." The damming back of the lymph stream takes place according to Recklinghausen and to Borst because of a mechanical obstruction formed by cancer particles in the proximal lymph and venous channels. Those of us who have examined tissues affected secondarily with cancer can readily grasp the possibility of this occurrence.

Clinically all these theories on the spread of carcinoma avail but little in making a positive diagnosis of secondary ovarian carcinoma on the operating table. We find quite often unilateral or bilateral solid or semisolid ovarian tumors with smooth, intact outer surfaces, not adherent to any other organ or structure, and without any perceptible local evidences of malignancy; and we cannot decide from the macroscopic appearance of the tumor whether it is a primary and still less a secondary carcinoma. In the majority of such instances, a diagnosis of primary carcinoma is made, and we feel content that the malignant tumor has been radically removed, particularly if we remove the uterus and the opposite adnexa with it. But how often is this clinical impression or opinion reversed by subsequent histopathological studies, or by autopsy findings, which show that we have been dealing with a condition of secondary instead of primary ovarian cancer. Have we any guides which will lead us out of this clinical perplexity?

Kroemer offers as a diagnostic aid in the differentiation between primary and secondary ovarian carcinoma, the presence of enlarged retroperitoneal lymph glands and the freedom of the peritoneal cavity from cancer involvement. These are indeed valuable signs, but I have encountered instances in which the involvement of the retroperitoneal glands has been so slight as to escape our palpatory sense; and concerning the peritoneal involvement I have shown that while the serosa may appear normal macroscopically, it shows advanced involvement when subjected to microscopic examination. These diagnostic aids are therefore of little value at the time of greatest importance, namely, the time of operating; for if we are dealing with a secondary condition, it would be foolhardy to attempt radical procedures which may result in immediate fatality. On the other hand, if the ovarian cancer is primary, operative risks are more justifiable, for in some instances life has been prolonged for many years after a thorough removal of the primary focus. A correct diagnosis is also of inestimable importance, for experience has taught that in uni-

Fig. 14. No. 3973. Papillary adenocarcinoma of the ovary. At *N.*, the epithelium covering the papilla still has a normal appearance, while at *M.* it is definitely malignant. The transition of the papillary into the adenomatous type is shown at *Aden.*, where the surface epithelium burrows its way into the underlying stroma and forms glandular structures. ×30.

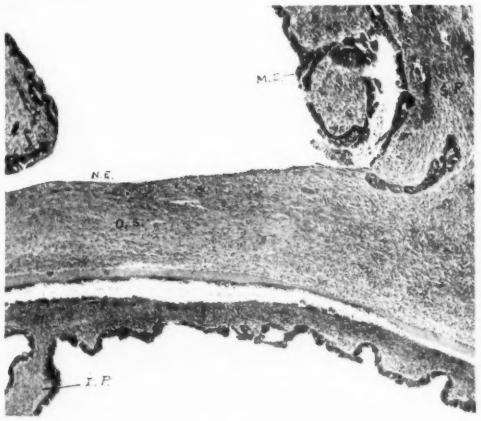


Fig. 15. No. 3973. Papillary adenocarcinoma of the ovary. Part of the cyst wall composed of ovarian stroma, *O.S.*, which is normal; the outer surface is covered with a low cuboidal normal epithelium at *N.E.* To the extreme right there springs a surface papilla, *S.P.*, covered with malignant columnar epithelium, *M.E.* The internal papillæ, *I.P.*, take their origin from the lining epithelium of the cyst, and have no structural connection with the surface growths. ×35.

lateral primary ovarian cancer, it is best to remove the opposite apparently normal ovary.

HISTOPATHOLOGICAL AND CLINICAL STUDIES OF SECONDARY OVARIAN CANCER

CASE 1. Path. No. 1282. D. F., aged 33 years, came under my care on May 6, 1923, complaining of a progressive enlargement of the abdomen for the past 8 months and of attacks of cramp-like pains in the epigastrium. Patient had been married 14 years; was a IV-para. The last child was born 8 months ago. She also miscarried once 14 years ago. Menses began at 14 years, were of 6 to 7 days' duration, moderate, and painless. The last period occurred before the last conception in January, 1922. Patient was operated for acute mastitis in December, 1922, and for a left inguinal hernia in March, 1923. She stated that at the time of her last operation, 3 months ago, the surgeon did notice an abdominal tumor, but did not consider its removal as urgent.

Physical examination reveals the following: a thin, frail individual with an enlarged abdomen containing a great deal of free fluid and two globular tumors in the lower half. The tumor on the left reaches a height of 2 inches above the umbilicus, and the one on the right extends slightly below the umbilicus. The vaginal outlet is relaxed, the cervix is lacerated, and the lips are everted and eroded. The uterus is normal in size and outline, anteverted, and wedged in between the two globular tumors. The smaller tumor occupies the hollow of the sacrum, and the larger one is in front and to the left of the uterus.

On May 7, 1923, I performed an abdominal panhysterectomy and a bilateral salpingo-oophorectomy. The peritoneal cavity contained a large quantity of free serous fluid. No visible or palpable metastatic nodules were present in any part of the abdominal cavity. The postoperative recovery was uneventful.

Pathological findings were as follows: The specimen (Fig. 27) consists of the uterus and its adnexa. The ovaries are converted into heavy, solid globular tumors, of an irregular wavy outline, covered with a smooth glistening serosa. The left tumor is as large as a cocoanut, while the right one as big as an adult's fist. On cross section, the tumors present a very dense structure, of a yellowish color. The fallopian tubes lie stretched across the upper anterior surface of each ovary and look normal. The uterus has also a normal appearance. The epithelium covering the ovaries is normal, low cuboidal in form. Most of the identifiable follicles contain degenerated ova. The ovarian stroma (Fig. 28) is œdematous, and many of the lymphatic spaces are dilated and filled with plugs of cancer tissue. The endometrium is normal, but the muscularis (Fig. 29) is invaded with cancer either in the form of single cells lying in the tissue clefts or as large cancer nests within the lymphatics. The cervix is normal. The fallopian tube (Fig. 30) also shows a marked cancerous invasion of the submucosa and the tubal wall, but the lining epithelium is normal.

Soon after the diagnosis of ovarian cancer (without any designation by the pathologist as to its primary or secondary nature) was established, prophylactic deep X-ray therapy was instituted, in the hope

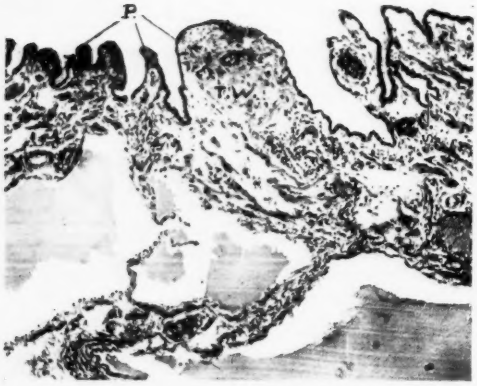


Fig. 16. No. 3533. Fallopian tube in a case of papillary adenocarcinoma of the ovary. The serous surface is thrown into small and large folds carrying the underlying stroma with it and forming papillæ, *P*. The serosa also dips into the tube wall, *T.W.*, and forms adenomatatous spaces, *A.S.* ×35.

that the case was one of primary ovarian cancer. In January, 1924, patient showed a gain of 30 pounds in weight, felt well, except for the vasomotor disturbances caused by the surgically induced menopause. A physical examination of the abdomen and the pelvis at this time failed to disclose any evidences of recurrence anywhere. A second vaginal and abdominal examination made in May, 1924, also proved to be negative, but she complained of slight discomfort in the epigastrium after meals. After this visit the patient refused to return for further

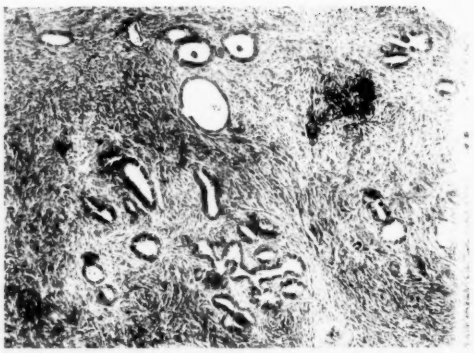


Fig. 17. No. 2346. Benign papillary adenoma of the l ovary, the right one being the seat of a papillary aden carcinoma. ×30.

observation. My last inquiry concerning her pro ress brought the information that she was operat on for a supposed acute cholelithiasis at the Wyc Heights Hospital, Brooklyn, in September, 192 and a carcinoma of the head of the pancreas w found. She died in that institution shortly after.

This single case contains an abundance o theoretical and practical knowledge pertain ing to the subject of primary and secondar ovarian cancer. At the time of the operatio I diagnosed the case as one of primary ovaria cancer, and the pathologist was in apparen

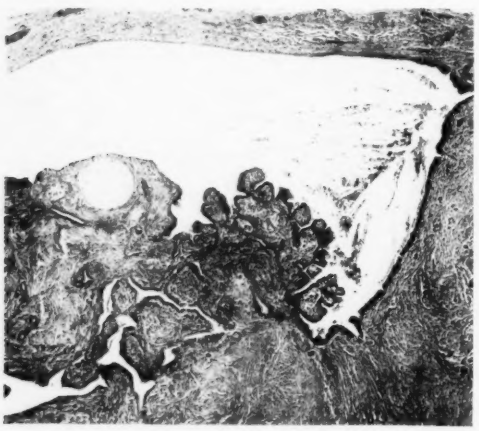


Fig. 18. No. 2346. A large cystic space within the substance of the left ovary, lined with low cuboidal and columnar epithelium, with a tuft of papillæ projecting into its interior; the opposite ovary being affected with an adenocarcinoma. ×30.

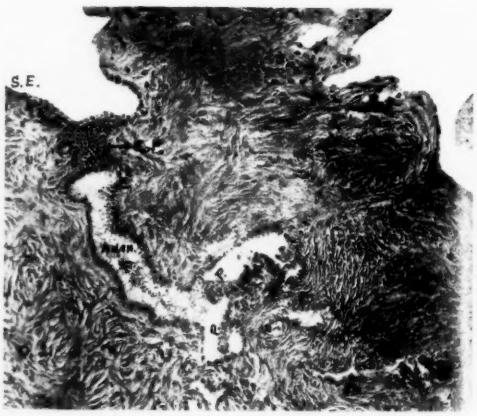


Fig. 19. No. 2346. The surface epithelium, *S.E.*, fus with the epithelium of the adenomatous spaces, *Aden.Sp* in the interior at *E.F.* There is also a large surface papill *S.P.*, having no structural continuity with the papillæ, *P* forming within the deep adenomatous spaces. ×40.

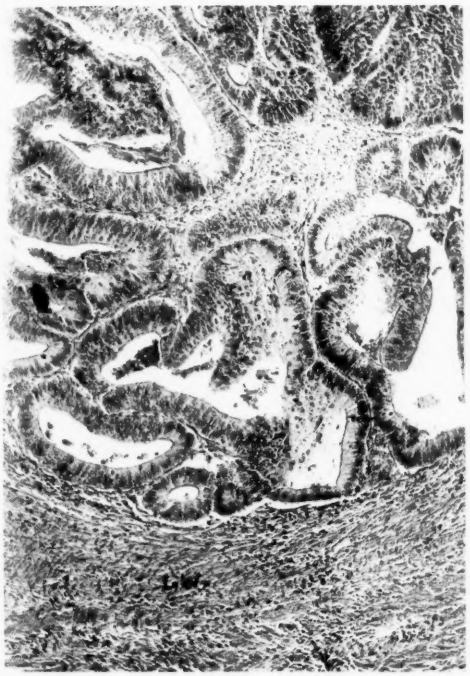


Fig. 20. No. 8346. Carcinoma of the sigmoid, removed 8 months after an operation for primary adenocarcinoma of the right ovary. The intestinal wall, *I.W.*, is not involved. ×35.

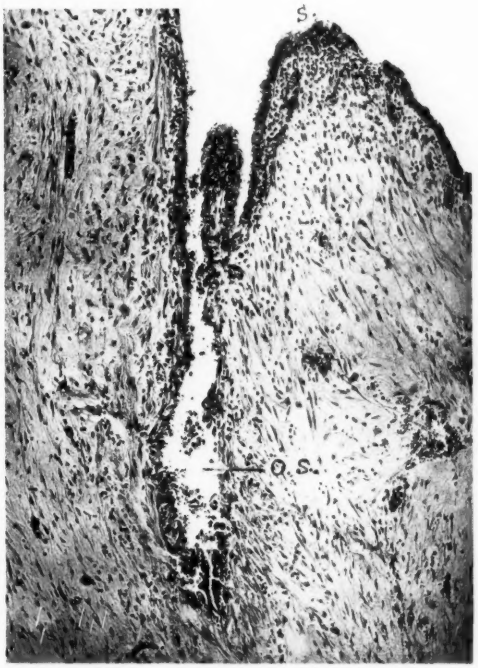


Fig. 21. No. 10173. Papillary adenocarcinoma of the ovary. The serosa, *S.*, shows a malignant metaplasia; it dips into a surface crypt and invades the ovarian stroma, *O.S.*, from without. ×45.

accord with the clinical impression. Although bilateral involvement should have suggested the possibility of a secondary character, notwithstanding the fact that the primary focus was not visible or palpable, I was rather influenced in my judgment by the macroscopic findings, and have considered the case as one of primary ovarian cancer. The reason for this error is the same as that which misleads other abdominal surgeons, namely, that the largest tumor is considered as the primary focus. In most instances this clinical assumption is justified, but not in secondary ovarian carcinoma. O. Frankl has called our attention to the clinical fact that ovaries secondarily affected with carcinoma may attain dimensions which exceed by far the size of the primary cancer focus, and I may add long before the primary focus gives rise to physiological disturbances. This case illustrates the

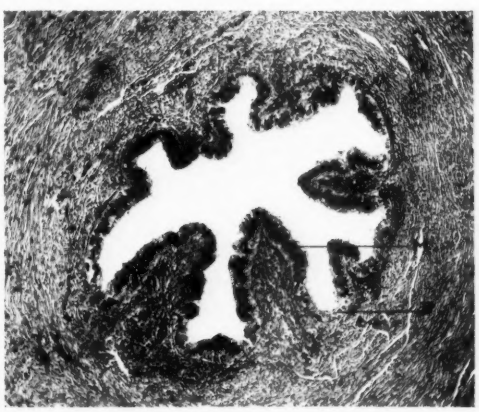


Fig. 22. No. 10173. A cross section of a fallopian tube associated with an adenocarcinoma of the corresponding ovary. Note transition of lining epithelium from a benign, *B.*, to a malignant, *M.*, stage. Lymph spaces and blood vessels in tube wall are free from cancerous invasions. There is a moderate lymphocytic infiltration in submucosa. ×37.

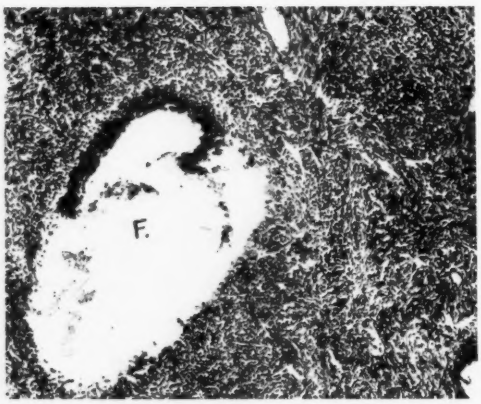


Fig. 23. No. 4151. Granulosa cell cancer of the left ovary, in a case in which the right ovary was the seat of a papillary adenocarcinoma. Note the large follicular cyst, *F.*, and the proliferation of the granulosa cells from its walls into the surrounding stroma. ×35.

Fig. 24. No. 4151. The endometrium in a case in which the right ovary was the seat of papillary adenocarcinoma, and the left ovary affected with granulosa cell cancer. At *M.E.* malignant epithelium, while at *N.E.* the epithelium looks normal. ×30.

soundness of these claims. The carcinoma of the pancreas from which this patient died 1 year after the removal of the ovarian cancer, must have been so small in size that it gave no evidences of physical or functional disturbances, yet it was capable of producing massive metastasis in the ovaries.

Not only do the dimensional disproportions between the primary focus and the secondary growth in the ovaries mislead us clinically in making a correct diagnosis, but pathologists are often guilty of perpetuating this error, by not stating definitely in their reports whether the ovarian cancer was primary or secondary. It has also happened to me that when the pathologist has stated the nature of the ovarian cancer his opinion has been reversed by subsequent findings. Can we be certain as to whether an ovarian cancer is primary and secondary?

My investigations have shown that secondary ovarian cancer is characterized by the non-participation of the epithelial elements of the generative organs in the cancer metaplasia. The cancer tissue in secondary ovarian, tubal, and uterine carcinoma, is located within the lymph spaces or blood vessels of the stroma, and the lining epithelium of these organs presents a normal appearance. It is only in the very advanced stages of the cancer metaplasia in the invaded organs that a correct pathological diagnosis becomes difficult; in the earlier stages, however, the differentiation between primary and secondary carcinoma of the generative organs should not present a problem.

Are there any clinical signs and symptoms indicating or suggesting the type of ovarian cancer? If there is any tangible relationship between growth and function, and if tumors assume the function of the organs from which they spring, then ovarian cancer ought to furnish a most illuminating example of this morphobiological concept. In granulosa cell cancer, and to a much lesser degree in papillary adenocarcinoma of the ovary, we have noted an increase of the present ovarian function or its revival after it has been suspended for short or long interval of time. In secondary ovarian cancer on the other hand, even when the tumors have reached large dimensions the ovarian function remains undisturbed, or

Fig. 25. No. 3785. The left ovary from a case in which the right was the seat of papillary adenocarcinoma. Note the cystic degeneration of the follicles, each of which is surrounded by a distinct theca externa. The largest follicle cyst shows a papillary proliferation from the lining mucosa toward the lumen. In the other cystic follicles the granulosa cells are still recognizable. ×10.

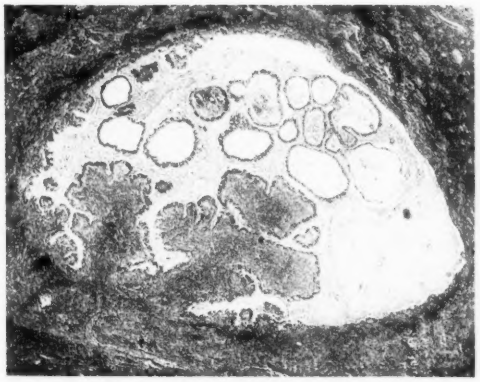


Fig. 26. No. 3785. Papillary and papillary adenocarcinoma in a cystic follicle. Under higher magnification the granulosa character of the lining epithelium is discernible at the extreme left. At other points of the circumference we can note the earliest beginnings of papillary formations, which are gradually enlarging to bigger dimensions. ×15.

is undergoing gradual extinction. The case presented here illustrates this fact. This patient was only 33 years of age, and at the time of the operation for the ovarian carcinoma, 17 months after her last confinement, the menses had not been re-established and she did not nurse her infant. It is true that in granulosa cell cancer, we have found in some instances an increase in the ovarian function, or its reappearance in women in whom the menses have not occurred for some time. I believe that these clinical phenomena should serve us in making a differential diagnosis between primary and secondary ovarian cancer.

GENERAL CONCLUSIONS AND DEDUCTIONS

1. The histogenetic source of granulosa cell cancer is the epithelium of the graafian follicles, and not the problematic fetal rests, the medullary rays, and the rete ovarii, which do not exist in the ovaries of human adults.

2. The folliculoid, the medullary, and the solid forms of granulosa cell cancer are not different cancer types, but different growth phases in the evolutionary process of one and the same tumor.

3. The outstanding morphological differentiations between the granulosa cell cancer and other types of ovarian carcinoma are: (a) the rotundity and uniformity of the epithelial cells (during the early phases of the tumor growth); (b) the rarity of mitosis; and (c) the absence of invasive and destructive propensities in the granulosa cancer.

4. Primary ovarian cancer, particularly the granulosa type, may augment the still active ovarian function or revive it after it has been quiescent for a short or long period of time, which manifests itself clinically by an hyperactivation of the endometrium, resulting in an increase of the normal menstrual flow, or in the reappearance of periodic uterine bleeding after the establishment of the menopause. Secondary ovarian cancer does not influence the ovarian function at first, but later on, as the disease progresses, it has a tendency to suppress it progressively, as the volumetric proportions of the cancer metastases rise.

5. The differences in the influence which primary and secondary ovarian cancer have respectively upon ovarian function, emanate from the differences in their histopathology. As the primary ovarian cancer is a derivative of the generative elements in the ovary, such cancer is endowed with the same hormone producing properties as the parent tissue, so that with an increased hyperplasia of this type of tissue, the hormonic index rises. On the other hand, the epithelium in secondary

Fig. 27. No. 1282. Metastatic carcinoma of the uterus, the ovaries, and the tubes.

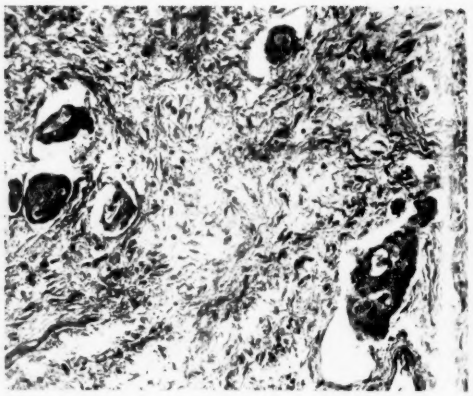


Fig. 28. No. 1282. Secondary cancer of the ovary. Ovarian stroma œdematous, the cancer nests are within the lymph spaces. ×75.

cancer of the ovary is of an extra-ovarian genesis, and therefore it has no relationship to ovarian function, which it leaves either uninfluenced, or annihilates it in the course of time through the physical destruction of the generative elements in the ovary.

6. As a corollary to the structural and functional relationship observed in primary ovarian cancer (granulosa), it would seem worth while to test the blood of patients suffering from ovarian neoplasms for an increased or diminished content of ovarian hormone, as an aid in the differential diagnosis between primary and secondary malignant affections of the sex gland.

7. The histogenetic sources of benign and malignant papillary tumors and papillary adenomatous tumors of the ovary are the surface epithelium of the ovary, the epithelium lining its cyst cavities, and the epithelium of cystic follicles. This fact overthrows the dictum that follicles do not give rise to neoplasms.

8. The simultaneous formations of benign and malignant papillary formations within cystic follicles, ovarian cysts, and upon the surface of the ovaries and the similar affections of the lining epithelium of the uterus and the fallopian tubes, and of the epithelium covering these organs substantiates and verifies the common genetic source of all these variously located and metamorphosed epithelial centers, which are equally influenced by the same biological factors.

9. Surface papillæ may be the continuations of intracystic growths which have perforated the wall, but in all my studies I have found them to be independent growths arising from the outer layers of the cyst wall and its overlying epithelium.

10. The finding of normal epithelium adjacent to malignant in papillary tumors, would lead us to assume that the transition from a benign to a malignant state is a sudden one, for we cannot detect by the ordinary microscopic means employed the finer biochemical changes that ensue within the cells before the structural features of malignancy become patent; in reality, however, this transition is a gradual one. Biochemical tests and not morphological criteria will have to determine early malignancy in the future.

11. The clinical assumption that the ovarian cancer is primary because the surface epithelium is intact and because the ovarian tumor is not adherent to any of the adjacent organs or tissues is ill founded. On the contrary, in most instances these findings indicate metastatic carcinoma, and the abdominal surgeon should attempt to find the primary focus.

12. The extension of the papillary growth from the ovarian surface to neighboring viscera should not discourage us from proceeding with a thorough removal of the tumor, if consistent with safety; for in many instances radical conservatism has yielded the most gratifying results.

13. In view of the successive nature of primary ovarian carcinoma, it is imperative

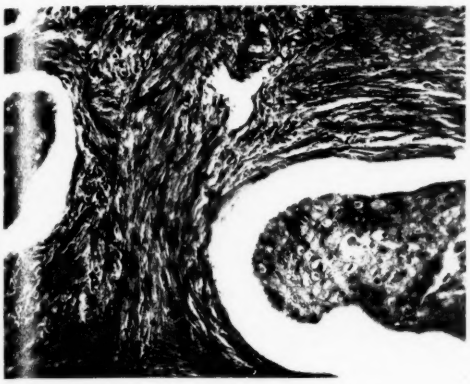


Fig. 29. No. 1282. Uterine wall in a case of secondary carcinoma of the ovaries. The lymph spaces are distended with large cancer plugs, and single cancer cells are also seen in the tissue interstices. ×75.

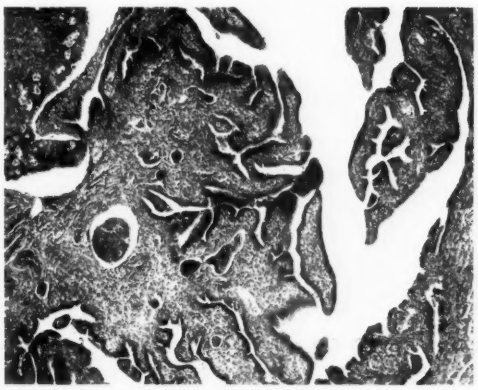


Fig. 30. No. 1282. Fallopian tube in a case of metastatic cancer of the ovaries. The epithelium covering the villi is normal, and the cancer deposits are within the small and large lymph spaces of the tube wall and submucosa. ×30.

to remove the opposite ovary and the uterus when operating for an apparently unilateral ovarian malignancy.

14. The prognosis of ovarian cancer in general may be based upon the histopathological observations made by McCarty, Martzloff, and others, namely: (1) cell differentiation; (2) lymphocytic infiltration; (3) fibrosis; and (4) hyalinization. Accepting these morphological criteria as prognostic guides, I have found that the granulosa cell cancer is the most benign, for we seldom find in it mitosis, lymphocytic infiltration, or fibrotic or hyaline degeneration. The absence of these phenomena is easily explainable; it does not signify a paucity or lack of defensive mechanism by the host, for these structural phases are defense mechanisms but a benignancy of the cancer. The close morphological resemblance of the granulosa cell carcinoma to the granulosa of the follicles does not make the proliferation of these cells quite foreign to the ovarian tissue; hence no necessity for defense reactions. The biological phenomena associated with granulosa cell cancer and its clinical course further substantiate its comparative benignancy.

In papillary adenocarcinoma of the ovaries, the prognosis is by far less favorable. The neoplastic tissue is morphologically further removed from its genetic source than the granulosa type of cancer. Its invasion of the surrounding tissue is, therefore, resisted more forcibly. The defense mechanisms are mobilized much more intensely, and we find a marked lymphocytosis. The degree of the lymphocytic reaction varies with the degree of differentiation of the proliferating epithelium. Hyalinization and fibrosis I did not observe in papillary adenocarcinoma of the ovaries.

15. Metastatic ovarian cancer is the most malignant, the reactions in the ovaries are most pronounced, and the removal of the ovaries does not eradicate the root of the disease.

BIBLIOGRAPHY

1. Acconci. Beitraege zue Histologie und Histogenese des papillar Cystoms des Ovariums. Centralbl. f. allg. Path., 1890, xxiii, 738.
2. Aschner, B. Ueber einen eigenartigen Ovarialtumor aus der Gruppe der Follikulome. Arch. f. Gynaek., 1922, cxv, 350.
3. Amann. Ueber Bildung von Ureiern und Primordialfollikelaehnlichen Gebilden im senilen Ovarium. München. Zentralbl. f. Gynaek., 1899, xlii, 1287.
4. Idem. Ztschr. f. Geburtsh. u. Gynaek., 1909–1910, lxv, 76.
5. Idem. Ueber sekundaere Ovarialtumoren. Muenchen. med. Wchnschr., 1905, ii, 2414.
6. Burckhardt. Zur Genese der multilokulaeran Ovarialkystome. Arch. f. path. Anat., 1896, cxliv, 148.
7. Blau, A. Follikuloma ovarii. Arch. f. Gynaek., 1926, cxxviii, 506.
8. Bremer. Das Oophoroma follikulare. Frankfurt. Ztschr. f. Path., 1907, i, 159.

9. Broders, A. C. Squamous cell epithelioma of the lip. J. Am. M. Ass., 1920, lxxiv, 656–664.
10. Idem. Cancer's self control. Med. J. & Rec., 1925, cxxi, 133–135.
11. Idem. Squamous cell epithelioma of the skin. Ann. Surg., 1921, lxxiii, 141.
12. Deaver, John B. Papillary cyst carcinoma of the ovary. J. Am. M. Ass., 1928, xci, 1008–1012.
13. Emanuel. Ueber maligne Ovarialtumoren mit Bildung von Primordialeiern. Ztschr. f. Geburtsh. u. Gynaek., 1893, xxvii, 62.
14. Fischel, A. Zur Eroeffnung des neuen Instituts fuer Embryologie. Wien. klin. Wchnschr., 1922, xxxv, 355.
15. Flaischlein. Zur Lehre von der Entwickelung der papillaeren Kystome oder multilokulaeren Flimmerepithelkystome des Ovariums. Ztschr. f. Geburtsh. u. Gynaek., 1881, vi, 231.
16. Flothow, Paul G. Defensive factors in carcinoma of the breast. Surg., Gynec. & Obst., 1929, xlvi, 789.
17. Frankl, O. Beitrag zur Pathologie und Klinik des Ovarialkarzinoms mit besonderer Berueckssichtigung des Carcinoma ovarii metastaticum. Arch. f. Gynaek., 1920, cxiii, 29.
18. Geist, S. H. A. A contribution to the histogenesis of ovarian tumors. Am. J. Obst. & Gynec., 1922, iii, 3.
19. Goodall, J. R. The origin of epithelial new-growth of the ovary. Surg., Gynec. & Obst., 1912, xiv, 584.
20. Idem. The origin of tumors of the ovary. Surg., Gynec. & Obst., 1920, xxx, 249.
21. Gottschalk. Ein neuer Typus einer kleincystigen boesartigen Eierstockgeschwulst. Arch. f. Gynaek., 1899, lix, 676.
22. Idem. Ueber das Follikuloma malignum ovarii. Berl. klin. Wchnschr., 1920, xxix, 607.
23. Greenough, R. B. Varying degrees in malignancy of cancer of the breast. J. Cancer Research, 1925, ix, 584.
24. Heuper, W. C. The relation of histological structure to the prognosis of carcinoma of the uterine cervix. Surg., Gynec. & Obst., 1928, xli, 502–511.
25. Hoffmeier. Die Krankheiten der weiblichen Geschlechtsorgane, 1893, 2d ed., 511.
26. Inguier. Kasuistische und kritische Beitraege zum sog. "Follikuloma ovarii." Arch. f. Gynaek., 1907, lxxxii, 545.
27. Kahlden, V. Ueber eine eigentuemliche Form der Ovarialkarcinome. Centralbl. f. allg. Path. u. path. Anat., 1895, vii, 650.
28. Krompecher, E. Ueber die Follikulome, Oophorome und Granulosazelltumoren des Ovariums. Ztschr. f. Geburtsh. u. Gynaek., 1925, lxxxviii, 341.
29. Lahm, W. Zentralbl. f. Gynaek., 1929, vii, 386.
30. Lauche, A. Heterotopische Epithelwucherungen an der Wand des Sigmoideum. Deutsche med. Wchnschr., 1922, clviii, 1331.
31. Idem. Die extragenitalen heterotopen Epithelwucherungen vom Bau der Uterusschleimhaut. Arch. f. Path. u. path. Anat., 1923, ccxliii, 298.
32. Lippmann. Ueber Eibildung in Carcinome des Ovariums. Ztschr. f. Geburtsh. u. Gynaek., 1904, lii, 248.
33. Lockhardt. Precancerous changes in rectum. Surg., Gynec. & Obst., 1928, clvi, 591.
34. Marchand. Habilitationsschrift. Halle, 1879. Quoted by C. Sternberg.
35. Martzloff, K. H. Carcinoma of the cervix uteri, a pathological and clinical study. Bull. Johns Hopkins Hosp., 1923, xxxiv, 141–149, 184–195.
36. McCarty, W. C. Carcinoma of the breast. Tr. South. Surg. Ass., 1911, xxiii, 262–270.
37. Idem. The histogenesis of carcinoma of the breast and its clinical significance. Surg., Gynec. & Obst., 1913, xvii, 441–459.
38. Idem. Clinical suggestions based on a study of primary, secondary and tertiary or migratory (carcinoma) epithelial hyperplasia in the breast. Surg., Gynec. & Obst., 1914, xvii, 284–289.
39. Idem. Factors which influence longevity in cancer. J. Lab. & Clin. Med., 1922, vii, 42–43.
40. Idem. Prognostic factors in cancer. Ann. Clin. Med., 1924, ii, 244–247.
41. Idem. A biological conception of neoplasia. Am. J. M. Sc., 1919, clvii, 657–674.
42. Meyer, Robert. Zur Histologie und Einteilung der Ovarialkystome. Ztschr. f. Geburtsh. u. Gynaek., 1916, cliv, 302.
43. Idem. Arch. f. Gynaek., cxxiii, 675.
44. Idem. Studien zur Pathologie der Entwickelung. i, 79–93.
45. Idem. Ztschr. f. Geburtsh. u. Gynaek., xliv, p. 32; lxv, 676; lxx, 329; lxxxv, 441. Ergebn. d. allg. Path., lx, 518. Verhandl. d. deutsch. path. Gesellsch., 1924, p. 559.
46. Neumann, H. O. Beitraege zur Kenntniss seltener Ovarialtumoren. Arch. f. Gynaek., 1927, cxxx, 742.
47. Olshausen. Ztschr. f. Geburtsh. u. Gynaek., xi, 235; liv, 160.
48. Pfannenstiel. Die Erkrankungen des Eierstocks und des Nebeneierstocks. Handb. f. Gynaek., 1908, iv, 180.
49. Pick, L. B. Klin. Wchnschr., 1902, xxvi, 618.
50. Polano. Ueber Pseudo-epithelioma des Eierstocks. Ztschr. f. Geburtsh. u. Gynaek., 1904, l, 1.
51. Robinson, M. R. A critique on the histogenesis of heterotopic endometrial proliferations. Surg., Gynec. & Obst., 1925, xli, 36–38.
52. Seifried. Ztschr. f. Krebsforsch., 1923, xx, 236.
53. Sinety de et Malassez. Sur la structure et l'origine de development des cystes de l'ovarie. Arch. d. Physiol., 1878, v, 39.
54. Sistrunk, W. E., and McCarty, W. C. Life expectancy following radical amputation for carcinoma of the breast. Ann. Surg., 1922, lxxv, 61–68.
55. Steffek. Zur Entstehung der epithelialen Eierstocks Geschwuelsten. Ztschr. f. Geburtsh. u. Gynaek., 1890, xix, 236.
56. Sternberg. Biologie und Pathologie des Weibes, by Halban and Seitz. Berlin and Vienna: Urban and Schwarzenberg, 1926. Vol. ii, p. 746.
57. Stratz. Zur Histologie der epithelialen Geschwulsten. Ztschr. f. Geburtsh. u. Gynaek., 1893, xxvi, 1.
58. Tarildoroff. Quoted by Ulesko-Stroganowa.
59. Taylor, Howard, Jr. Malignant and semimalignant tumors of the ovary. Surg., Gynec. & Obst., 1929, xlviii, 204–230.
60. Ulesko-Stroganowa. Follikuloma ovarii v carcinomatoides. Arch. f. Gynaek. u. Geburtsh., 1923, cxxi, 340.
61. Voigt. Ueber Carcinoma follikuloides ovarii. Arch. f. Gynaek., 1904, li, 1.
62. Walthardt. Zur Aetiologie der Ovarialadenome. Ztschr. f. Geburtsh. u. Gynaek., 1903, xlix, 233.
63. Warburg, O., Wind, and Negelein. Stoffwechsel bei Krebskranken. Klin. Wchnschr., 1926, p. 82.
64. Werdt. Ueber die Granulosazellentumoren d. Krebskranken Ovariums. Beitr. z. path. Anat. z. allg. Path., 1914, lix, 452.

A BACTERIOLOGICAL STUDY OF THE VALUE OF MERCUROCHROME AS A VAGINAL ANTISEPTIC WITH PARTICULAR REFERENCE TO ITS USE IN OBSTETRICAL CASES[1]

H. W. MAYES, A.M., M.D., AND SILKA ULLIAN, BROOKLYN, NEW YORK
From the Obstetrical Department of the Methodist Episcopal Hospital

DURING the past 20 years comparatively little attention has been paid to the sterilization of the birth canal preparatory to delivery, and there has been no general marked change in the morbidity and mortality figures. De Lee (1918) has stated that one woman in every 400 deliveries succumbs to infection and ten times this number remain incurable invalids. Statistics show that one-third of the mortality in the United States is due to puerperal infection.

An increasing amount of data, however, is tending to show that the birth canal is frequently contaminated by pathogenic organisms. Thus, Joetten (1912) examined 100 cases and found that streptococci, which often were of the hæmolytic type, were present in 67 per cent of the vaginal secretions.

Fricke (1914), working under Williams, examined 97 patients. Of 50 clinic patients, streptococci were found on the vulva in 14 per cent and in the vagina in 8 per cent. Forty seven patients were examined in their homes and the vulva found to be contaminated with streptococci in 75 per cent. The vagina was similarly contaminated in 55 per cent of the cases. The low figures in the first series were attributed to the use of unsuitable culture medium.

Burt-White and Armstrong (1928) took vaginal cultures from 153 pregnant women and succeeded in isolating streptococci in 23.5 per cent of the cases. Organisms were obtained in 35.9 per cent under anaerobic culture conditions. Of these, many were hæmolytic.

Bigger and Fitzgibbon (1925) similarly examined swab material from the vaginas of 158 women, either on admission or shortly afterward. In the majority of these cases labor had already commenced. Streptococci were present in 101 cases, but the hæmolytic type was found only twice in 108 specimens. The authors believe that the commonest form of puerperal sepsis is due to exogenous infection.

A study of cultures taken from 50 uteri at cæsarean section by Harris and Brown (1927) gave positive results in 22 cases. In 13 of these patients, there had been no vaginal examination. The membranes had ruptured in 15 cases prior to the operation. The authors are of the opinion that every patient in labor for more than 6 hours should be considered potentially infected, since they were able to obtain pathogenic organisms from the uterus in all such cases.

Albert (1927) reports 20 cases in which cultures were taken from the placenta and fetal membranes immediately following cæsarean section. All the placenta cultures were negative. The decidual cultures were all positive except one. In 7 cases, streptococci, staphylococci, and pneumococci were found.

Harris (1922) reported the results of histological examinations of 60 uteri. In 23 of the specimens there was definite evidence of ascending infection, and many of the stained preparations showed bacteria. These figures deal with late removal after a trial delivery. Further investigation showed that the number of infections depended on the length of labor.

A large percentage of amputated uteri showed acute inflammation of the decidua according to Williams (1917).

The work of Johnson and Siddall (1922) tends to show that the generally accepted preparation of today is not what it should be.

Walthard (1919) reported that positive cultures were obtained from amniotic fluid and uterine secretions in 15 cases at cæsarean section.

In the report (1923) of the Committee of the Massachusetts Medical Society, on maternal and infant welfare, it is stated that approximately one-half of the deaths which

[1]This study was made possible by the income of the Lindridge Research Fund.

occurred following cæsarean section were due to infections of various kinds. It is further reported that over one-fifth of the obstetric deaths were due to sepsis.

Blacker (1921) found that while the mortality in 469 clean cases at cæsarean section was only 2.9 per cent, yet in 230 cases in which the membranes were ruptured or in which frequent examinations or attempts at delivery had been made, the maternal mortality was as much as 17 per cent. He indicates that the possibility of the mother being infected in such cases is extremely high and that the mortality may vary from 11 to 27 per cent.

Holland (1921) states that the chief cause of imperfect healing of the uterine wound in cases at cæsarean section is infection.

DeNormandie (1923) states that sepsis accounts for the large majority of deaths following cæsarean sections.

This is an era of preventive rather than of curative medicine and, in view of these and other findings, we believe that the birth canal should be regarded as potentially contaminated by pathogenic organisms, especially in cases in which labor is prolonged and in which examinations have been conducted. It has, therefore, seemed desirable to instill an antiseptic solution in every case. In our hands mercurochrome has proved to be almost ideal for this purpose.

After a clinical experience with mercurochrome extending over a period of 5 years, we are convinced that the use of this germicide has been the chief factor in reducing puerperal morbidity and mortality in our service. One of the authors (1929) has previously reported that the morbidity had been reduced from 12.3 per cent in 1923, when iodine was used in preparation of the perineum, to 5.1 per cent in 1928, when this substance was replaced by mercurochrome. There has been a decline of almost 60 per cent in the incidence of morbidity following the introduction of the mercurochrome technique. Our experience has covered a total of about 9,000 cases. It has further been stated (1926) that material removed from the vagina by means of sterile swabs, and cultured, often showed no growth from 24 to 48 hours after the instillation.

Since the original report on the use of mercurochrome in obstetrics was published (1925), many hospitals and physicians have used our technique. The findings as evidenced by personal communication and frequent reference in the literature have been encouraging. During the past 5 years, a 4 per cent solution of mercurochrome has been used as a vaginal antiseptic during labor and before delivery in all obstetrical cases at the Methodist Episcopal Hospital.

Articles have appeared in the journals during the past few years in which the authors state that iodine is more efficient as an antiseptic than mercurochrome. Our experience has been, however, that mercurochrome is far superior to iodine as an antiseptic in obstetrical work. Iodine is often destructive to tissue and dermatitis is not infrequent. Mercurochrome, on the other hand, is not injurious even to the delicate mucosa of the birth canal and in no case have we observed any untoward effects in either the mother or child following its application. We believe, from our experience with mercurochrome, that its use in the vagina undoubtedly destroys a large number of bacteria and that it remains in sufficient strength to inhibit the growth of such organisms as are not immediately killed. Inhibition is exerted to such an extent that the normal defense mechanism of the body resists infection.

A number of articles have appeared in various journals dealing with the use of antiseptics in the birth canal. Ott (1925) has recommended that the vagina be disinfected in all labor cases, especially in long labors. Mercurochrome is suggested as a good disinfectant for this purpose. Lull (1927) states that in patients who have been in labor or have been examined, the external genitalia are treated with 3.5 per cent tincture of iodine and the vagina and cervix with 3 per cent solution of mercurochrome. Bessessen and Bessessen (1929) state that every patient in labor must be approached as a surgical operation. All should receive some antiseptic preparation intravaginally early in labor. De Lee (1928) reports that 9 of 12 gauze packs, saturated with mercurochrome before introduction, when removed, were found sterile.

Bailey (1928) reported that the morbidity rate in patients who were instilled with mercurochrome before vaginal examinations was lower than in other cases, and states that he has used mercurochrome injections more and more freely since the original report on the method by Mayes. Goodall and Wiseman (1928) have reported very gratifying results from the use of a technique similar to that of Mayes.

In view of the mass of clinical evidence favorable to our technique and the almost complete lack of bacteriological data, a laboratory investigation was undertaken.

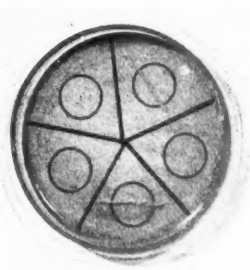


Fig. 1. The plate is divided in five sectors in which are the circles where the cultures are made. The streaks across two of the circles represent the growth of the control culture referred to under "Controls."

PROCEDURE

The original plan was to take cultures from the perineum, labia, vagina, and cervix when the patient was admitted. These cultures were to serve as controls. Cultures were taken after the perineum had been sprayed and the vagina instilled with mercurochrome and again following delivery. This general scheme has been carried out as far as possible. The fact, however, that many cases were delivered during the night or shortly after admission made it difficult at times to obtain these cultures, particularly in view of the changing house staff. We, therefore, finally laid most stress on cultures which were taken after delivery. If the cervix and vagina are sterile at this time, the chances of infection are greatly reduced because a good leucocytic protective zone is established before pathogenic organisms can reach the uterus.

All cultures were taken with sterile swabs and transferred to blood agar plates; the agar being a prepared nutrient phosphate agar with hydrogen-ion concentration of 7.4 to 7.6. In preparing the medium, 1 cubic centimeter of blood and about 15 cubic centimeters of melted agar were thoroughly mixed and poured into sterile Petri dishes. This medium was used exclusively for our cultures. The base of the Petri dish was then divided with a glass pencil into five sectors labeled 1, 2, 3, 4, and 5 (Fig. 1). In section one, the perineal culture was grown; in section two, the labial culture; section three, the vaginal culture; section four, the cervical culture; and section five, the culture taken from the maternal side of the membranes along the torn edge. The swab was streaked over a circular area about 2 centimeters in diameter in the center of each sector. By limiting the area of growth in this way, it was easy to recognize any possible external contamination of the plates. After the cultures were applied to the agar, all plates were incubated at 38 degrees C. for 48 hours before readings were taken. The colonies were inspected microscopically but all diagnoses were made from stained smears by use of the ordinary staining methods.

CONTROLS

In view of the large number of negative plates obtained after the use of mercurochrome, the question arose as to whether enough mercurochrome had been carried over to the culture medium to inhibit the growth of bacteria. Twenty-five control plates were therefore prepared. These plates were divided into sectors as before. Two of the sectors were marked "3" (vaginal) and two were marked "4" (cervical). The swab from the vagina was smeared in the small circles in the two sectors marked "3," and the cervical swab was similarly smeared in the two sectors marked "4." A fresh 24 hour broth culture of staphylococcus aureus standardized against phenol was streaked across one smear marked "3" and one marked "4," continuing for about 1 centimeter beyond the limits of the smeared spot. The smears on the second sections labeled "3" or "4," respectively were untouched and were allowed to develop as

TABLE I.—PRIMIPARÆ VERSUS MULTIPARÆ

	Primiparæ		Multiparæ	
	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens
Vagina	97	9.28	83	2.41
Cervix	97	5.15	83	3.61
Membranes	73	4.10	67	7.46

usual. These plates were incubated as before. In 23 of the 25 controls there was no perceptible difference in the amount of growth of the staphylococcus which appeared in the smeared area and that which appeared beyond it. In two cases the growth within the smeared area was very slightly less than that beyond; so little less, however, that it was considered negligible and large colonies developed in these areas also. It was, therefore, concluded that so little mercurochrome was carried over to the plate that it would not inhibit the growth of any living organisms which might be present.

CULTURED SWAB MATERIAL

Swab material taken from the skin of the perineum before the use of mercurochrome and cultured gave pathogenic organisms in 83.5 per cent of the cases. Pathogenic bacteria were similarly found in the vagina in 44.7 per cent, and of 55 cases in which material from the cervix was examined, 18.1 per cent yielded pathogens.

Results from the culture of perineal and labial swab material after the use of mercurochrome and following delivery may not be so reliable since there is a possibility of contamination of the perineum by discharge of fæces and shifting of sterile dressings. In 140 cases, however, cultures were taken from the skin in this region following delivery, and 25.9 per cent gave pathogens. In 100 cultures similarly taken from the labia pathogens were shown in 28 per cent of the cases. The labial region is often carelessly prepared, the depth of the folds interfering with proper cleansing.

The pathogenic organisms referred to in the tables included staphylococci, streptococci, and bacillus coli.

Non-pathogenic organisms also were found at times. These organisms consisted largely of yeast and the bacillus vaginalis.

Only pathogenic organisms are considered in this report.

It should here be pointed out that the apparent discrepancies in some of the tables dealing with the pathogenic bacteria found in different sites are due to the fact that it was often impossible to get a complete set of cultures from each patient.

PRIMIPARÆ VERSUS MULTIPARÆ (TABLE I)

There was a greater number of pathogenic bacteria found both in the cervix and vagina when the cultures were taken from the primiparæ, while in the cultures from the membranes, there were more positive pathogens in the multiparæ. With the primiparæ the labor is usually longer and more likely to be operative, while in the multiparæ the labor is of short duration, the cervix is likely to be dilated and lacerated and very often the seat of chronic infection. This would possibly account for the higher percentage of pathogens obtained in the membranes.

VAGINAL VERSUS RECTAL EXAMINATIONS (TABLE II)

From 11 patients there was only one positive pathogen found in 30 cultures taken following vaginal examinations. This may be due to the fact that during the vaginal examinations, the perineal preparation, as well as the instillation, is repeated. There was a low percentage of organisms following rectal examinations. This series included a large majority of the spontaneous deliveries, while the cases with vaginal and rectal examinations included the cases of prolonged labor and other evidences of dystocia. The cases with no examinations showed the highest average of pathogenic bacteria. This is due to the fact that the labor was usually short and that the mercurochrome was in-

TABLE II.—VAGINAL VERSUS RECTAL EXAMINATIONS

	Examination, vaginal		Examination, rectal		Examination, vaginal and rectal		No examinations	
	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens
Vagina	11	0	125	1.6	33	21.21	11	18.18
Cervix	11	9.09	125	4.0	33	3.03	11	9.09
Membranes	8	0	95	8.42	25	0	12	8.33

TABLE III.—DURATION OF LABOR

	Duration of labor in hours									
	0 to 6		6 to 12		12 to 18		18 to 24		Over 24	
	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens
Vagina	39	2.56	45	2.22	50	8.	21	4.76	25	16.
Cervix	39	2.56	45	8.88	50	2.	21	4.76	24	4.16
Membranes	29	17.24	37	2.7	39	5.13	16	6.25	19	0

stilled too near the time of delivery. It is impossible to instill a patient properly when the cervix is retracted past the presenting part or if the presenting part is on the perineum. The solution will not remain in the vagina nor does it come in contact with the cervix or the upper part of the vaginal mucosa. Referring to Table V it will be noticed that the percentage of positive pathogens was 18.18 per cent in 11 cases which were instilled at the time of delivery.

At the present time we are making a comparative study of the effect of vaginal and rectal examinations on the morbidity following the use of the mercurochrome technique. This will be published later.

DURATION OF LABOR (TABLE III)

The number of positive pathogens found in the vagina increased with the duration of labor possibly due to the contamination from without. The patients almost invariably put their hands on the perineum during labor, as is shown by the stain on their fingers. Bed clothes and rectal examinations may also tend to contaminate the perineum as labor progresses. At the hospital we use no protective perineal dressing during labor. With the cervical cultures there is an increase during the second 6-hour period, but then a marked drop to 2 per cent followed by a slight increase to between 4 and 5 per cent for those cases in labor over 18 hours. With the membranes there were 17.4 per cent pathogens when labor was less than 6 hours, again due to the fact that the mercurochrome did not have a chance to reach the membranes. There was a marked drop in the second 6-hour interval and in 36 cases in labor over 18 hours, only one positive pathogen was recovered.

RUPTURED MEMBRANES (TABLE IV)

With the vaginal cultures there was a steady increase in the pathogens found up to 18 hours, and in 36 cases with the membranes ruptured over 18 hours only one pathogen was found. In the cultures from the cervix the maximum number of pathogens was found at 12 and 18 hours, but in 36 cases with the membranes ruptured over 18 hours, there were only two positive pathogens. Cultures taken from the membranes showed that the greatest number of pathogens was recovered in the period from 6 to 12 hours and in 34 cultures when the membranes were ruptured in from 12 to 24 hours, only one positive pathogen was found.

Ruptured membranes have been considered one of the great factors in the production of morbidity. This is undoubtedly true when

TABLE IV.—RUPTURED MEMBRANES

	Ruptured membranes in hours													
	Under ½		½ to 6		6 to 12		12 to 18		18 to 24		Over 24		Unknown	
	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens
Vagina	52	1.92	67	5.97	17	11.76	8	37.5	6	0	10	10.	20	0
Cervix	52	5.76	67	1.49	17	5.88	9	11.11	6	0	10	10.	20	5.
Membranes	44	11.36	48	2.08	14	14.29	8	0	3	0	8	12.5	15	0

mercurochrome is not used. Sapræmia and even intra-uterine infection may develop at times, thus causing a definite morbidity even before the onset of labor. If the mercurochrome technique is used properly from the time of rupture, I believe that ruptured membranes play a very little part as to the cause of morbidity and the patient is not potentially infected.

TIME OF INSTILLATION (TABLE V)

Positive vaginal cultures were obtained in 18.18 per cent when the instillation was at the time of delivery. When the mercurochrome technique was first used at the hospital, the patients were all instilled at the time of delivery and the morbidity at the time was 12.2 per cent for the mercurochrome series, as compared with 10.8 per cent for cases of iodine preparation at the time of delivery. We were somewhat discouraged with the mercurochrome technique, but since we have been instilling the patients on admission to the hospital or at the onset of labor and every 12 hours thereafter, by means of a special asepto-vaginal syringe, the morbidity has decreased to 5 per cent. If the patients were instilled every 4, 6, or 8 hours, better results might have been obtained. But in a large active service, every 12 hours seems satisfactory. With 52 patients who were instilled before the time of delivery and had mercurochrome in the vagina less than 3 hours, the cultures were all considered negative. With the cervical cultures the largest number of bacteria was found when the instillation was less than 6 hours and then a steady increase up to 12 hours. Thirteen instilled over 12 hours were all negative. Cultures from the membranes showed the largest percentage of pathogens from 1 to 3 hours. In 37 cases instilled from 3 to 6 hours results were all negative and of 35 cases instilled over 6 hours, 4 or 7.2 per cent showed pathogens.

OPERATIVE VERSUS SPONTANEOUS DELIVERY (TABLE VI)

The vaginal cultures were positive in 9.52 per cent of cases following operative deliveries and 4.26 per cent in the spontaneous deliveries. The cervical cultures obtained were much less in the operative, while with the cultures from the membranes, the method of delivery made little difference.

CULTURES WITHOUT MERCUROCHROME TECHNIQUE

In order to check up on the antiseptic value of mercurochrome, a control series of 25 cases was prepared by shaving the perineum, cleansing with green soap and water and the use of Lysol as an antiseptic. In every culture from skin and labia, one or more pathogens were found. In the vagina seven times as many positive cultures were obtained as when mercurochrome was used; from the cervix, four times as many and from the membranes, five times as many. This would seem very definite proof as to the antiseptic value of mercurochrome. It is also interesting to note that the morbidity of the 25 cases without mercurochrome was 16 per cent or three times the average morbidity for the year 1928.

CÆSAREAN SECTION

Intra-uterine cultures were taken following cæsarean section. In 9 cases cultures were taken as near the cervix as possible and from the maternal surface of the membranes, attempting to get as near the cervix as possi-

TABLE V.—TIME OF INSTILLATION

	Length of time of instillation before delivery in hours											
	At delivery		Less than 1		1 to 3		3 to 6		6 to 12		Over 12	
	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens
Vagina	11	18.18	6	0	46	0	46	6.52	58	6.89	13	15.38
Cervix	11	0	6	16.66	46	2.17	46	4.30	58	5.17	13	0
Membranes	10	10.	4	0	36	16.66	37	0	44	6.82	11	9.09

TABLE VI.—OPERATIVE VERSUS SPONTANEOUS DELIVERY

	Spontaneous delivery		Operative delivery	
	Cases	Per cent positive pathogens	Cases	Per cent positive pathogens
Vagina	117	4.26	63	9.52
Cervix	117	5.98	63	1.58
Membranes	93	6.45	47	6.38

ble, and in no case was a positive culture obtained.

This is quite a contrast to the work of Harris and Brown at the Johns Hopkins Hospital in which they took 50 cultures following cæsarean section and of these, 22 were positive.

SUMMARY

A comparative study of the bacterial flora of the birth canal with and without the use of mercurochrome as a vaginal antiseptic showed that the number of positive cultures from the vagina was reduced from 44 per cent to 6 per cent; from the cervix, 16 per cent to 4 per cent; from the membranes, 32 per cent to 6.4 per cent.

Positive cultures were obtained in 26 different patients and in only one instance was there a positive vaginal and cervical culture in the same patient.

More positive cultures were obtained in primiparæ than in multiparæ.

Of 30 cultures taken from 11 patients who had only vaginal examinations, one was positive.

The cases with the vaginal and rectal examinations showed the most pathogens.

The number of pathogens in the vaginal cultures increased with the duration of labor, while with the cultures from the cervix and membranes this did not obtain.

With ruptured membranes the positive vaginal cultures increased up to 18 hours of labor, but in 36 cases in labor over 18 hours, only one positive culture was obtained from the vagina and two from the cervix.

In 34 cultures when the membranes were ruptured over 12 hours, one positive pathogen was found.

If the patients were instilled at the time of delivery, 18.18 per cent showed pathogenic organisms in the vaginal cultures, while 52 patients who had the mercurochrome in the vagina less than three hours, were all considered negative.

There were more than twice as many positive vaginal cultures obtained in the operative than in the spontaneous deliveries. With the cervical cultures, there were less in the operative.

In a control series of 25 cases in which no mercurochrome was used, seven times as many positive vaginal cultures were obtained, four times as many from the cervix and five times as many from the membranes. The morbidity was three times that of the year 1928.

Nine cultures taken from the interior of the uterus at cæsarean section were all negative.

CONCLUSION

These results undoubtedly prove that mercurochrome does reduce the bacterial content of the birth canal during labor, and even though the membranes are ruptured and labor prolonged, if the mercurochrome is instilled regularly and properly, the number of pathogens apparently does not increase either in the cervix or the membranes.

REFERENCES

1. Albert. Arch. f. Gynaek., 1927, cxxxii, 329.
2. Bailey, H. Am. J. Obst. & Gynec., 1928, April, p. 479.
3. Bessesen, D. H., and Bessesen, A. N. Surg., Gynec. & Obst., 1929, xlix, 220.
4. Bigger, J. W., and Fitzgibbon, F. J. Obst. & Gynæc. Brit. Emp., 1925, xxxii, 318.
5. Blacker, G. J. Obst. & Gynæc. Brit. Emp., 1921, xxviii, 449.
6. Burt, White, and Armstrong. Proc. Roy. Soc. Med. (Sect. Obst. & Gynæc.), 1928, xxi, 28–34.
7. De Lee, J. B. Principles and Practice of Obstetrics. 3d ed., p. 897. Philadelphia: W. B. Saunders Company, 1918.
8. Idem. Year Book of Obstetrics & Gynecology, 1928, p. 124.
9. DeNormandie, R. L. Boston M. & S. J., 1923, clxxxix, 1011.
10. Fricke. See Williams, J. W., Text-book of Obstetrics, 5th ed., p. 997, 1914.
11. Goodall, J. R., and Wiseman, Max. Am. J. Obst. & Gynec., 1928, September, 339.
12. Harris, J. W. Johns Hopkins Hospital Bull., 1922, September, p. 318.
13. Harris, J. W., and Brown, J. H. Am. J. Obst. & Gynec., 1927, xiii, 133.
14. Holland, E. J. Obst. & Gynæc. Brit. Emp., 1921, xxviii, 521.
15. Joetten. Zentralbl. f. Gynaek, 1912, p. 1529.
16. Johnson and Siddall. Am. J. Obst. & Gynec., 1922, p. 645.
17. Lull, C. B. Am. J. Obst. & Gynec., 1927, May, 637.
18. Massachusetts Medical Society Committee on Maternal and Infant Welfare. Boston M. & S. J., 1923, clxxviii, 288.
19. Mayes, H. W. Am. J. Obst. & Gynec., 1925, July.
20. Idem. New York State J. Med., 1926, xxvi.
21. Idem. Am. J. Obst. & Gynec., 1929, xvii, 645.
22. Ott. Monatsschr. f. Geburtsh. u. Gynaek., 1925, lxx, 257.
23. Walthard, M. Arch. f. Gynaek., 1919, cxi, 105.
24. Williams, J. W. Surg., Gynec. & Obst., 1917, xxv, 194.

SODIUM AMYTAL–NITROUS OXIDE ANÆSTHESIA FOR THYROIDECTOMY

FRANK B. RAMSEY, M.D., AND WENDELL D. LITTLE, M.D., F.A.C.S., INDIANAPOLIS, INDIANA
Department of Surgery, Indiana University School of Medicine

SODIUM amytal (sodium iso-amyl-ethyl barbiturate) has been introduced recently as an anæsthetic agent, and a comprehensive clinical trial of it is still in progress. We wish to present our opinion as to the advantages which appear to result from the sodium amytal-nitrous oxide combination in thyroidectomy and as well to tabulate the patients' reaction during and after administration. The first few experiences with anæsthesia from this drug convinced us how necessary it is to have a high degree of control over the anæsthetic agent. No matter what anæsthetic agent is used or in what manner it is administered, controllability is of first importance. For this reason just enough sodium amytal was given to induce sleep and nitrous oxide gas and oxygen were used to control the depth of anæsthesia.

From comparatively small doses of sodium amytal a light sleep was induced which was sufficient for preparation and preliminary measures. During actual operative manipulations nitrous oxide gas with an unusually high component of oxygen was given. The cyanosis, which is often a part of satisfactory nitrous oxide anæsthesia, did not occur when a proper amount of sodium amytal had been given. In our opinion this manner of using sodium amytal and nitrous oxide gas makes an ideal anæsthetic agent when marked relaxation is not necessary for the successful performance of the operation. Because of the flexibility of control and because of the absence of both anæsthetic depression and irritation of the respiratory tract, the combined use of sodium amytal and nitrous oxide gas seems particularly well adapted to operations

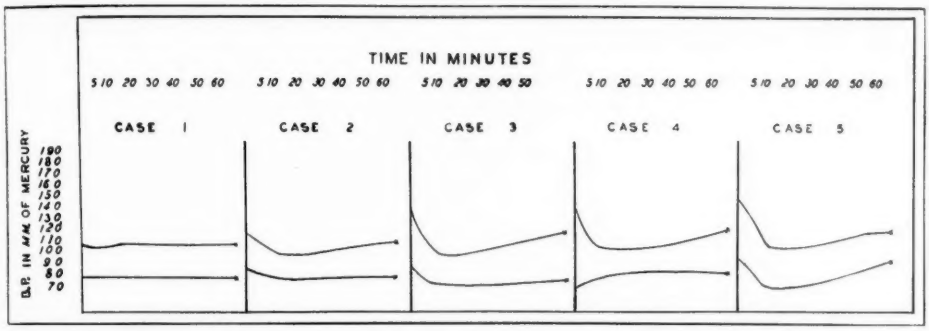


Fig. 1. Illustrates changes in blood pressure observed during intravenous administration of sodium amytal, injection of which occupied the initial 10 or 15 minutes on each curve. Blood pressure at completion of operative procedure is also indicated.

upon the thyroid gland and upon the chest, because marked relaxation of the muscles is not important. At least in so far as we are aware, these desirable features are not combined to the patient's advantage when any other anæsthetic agent is used. We have found in our experience that ethylene is constantly followed by a distressing degree of laryngeal irritation and a most disturbing amount of mucus; in fact, this complication appeared so constantly in greater or lesser degree when ethylene was used that for a time we felt that some part of the operative technique was at fault. With ether anæsthesia the same complication occurred at times but not regularly. While opinion differs widely as to the cause of this complication, it is agreed that it occurs frequently and is most undesirable. In this series of cases the presence of laryngeal mucus as a postoperative complication occurred only twice and then in mild forms.

We have used sodium amytal combined with nitrous oxide anæsthesia in 135 general surgical cases and in this report we wish to analyze in detail 27 consecutive cases of thyroid surgery performed with this type of anæsthesia. The series consists of 26 thyroidectomies (subtotal) and 1 double polar ligation performed at the Robert W. Long Hospital from February to August, 1929.

Sodium amytal was administered intravenously to 23 of these cases and by rectum in the 4 others. Table I contains a summary of the dosage employed. The dose of the drug given intravenously varied from 12 to 20 milligrams per kilogram of body weight; however, the majority received approximately 15 milligrams per kilogram (1 grain per 10 pounds body weight). Variations from the average dose were made at the time of injection in accordance with the patient's reaction to the drug. Considerable latitude in dosage was found necessary due to individual differences in reaction. Effectiveness was observed to vary with age, general health, and rate of metabolism, and the dosage required to induce a light sleep in each patient was best determined by the rate at which the subject became unconscious at the time of injection.

The drug was given by rectum in 4 instances and by this route a dosage of from 20 to 30 milligrams per kilogram was used. There is much to commend this method of giving the drug, but in the event that a portion of the dose is expelled subsequent dosage is difficult because the amount retained cannot be reckoned exactly. Also in the event of undue depression, the intravenous method is by far the safest, since the effect by this method is essentially instantaneous and the administration may be stopped immediately. If given rectally the removal of the drug would be a difficult if not an impossible procedure.

All these patients received in addition to the sodium amytal a pre-operative dose of morphine—10 to 15 milligrams (1/6 to 1/4 grain). This was combined with 0.5 milligrams of atropine sulphate (1/150 grain) in 8 instances.

TABLE I.—REACTION OF PATIENTS DURING AND AFTER SODIUM AMYTAL INJECTION

Case No.	Sex and age	Diagnosis	Basal metabolism	Dose of sodium amytal			Nitrous oxide-oxygen %	Remarks
				Milligrams per kg.		Total dosage in grains		
				Intravenously	Per rectum			
1	F. 39	Adenoma	−7 −7	15	..	15	80–85	
2	F. 34	Adenoma	+12	15	..	12	80–85	
3	F. 29	Adenoma	....	15	..	15	75–80	
4	F. 52	Adenoma	....	15	..	9	75–80	Postoperative auricular fibrillation.
5	F. 45	Adenoma	+14	12	..	12	80–85	Digitalized for auricular fibrillation pre-operatively. Slight fibrillation developed after operation.
6	F. 30	Exophthalmic	+62 +38	12	..	7	90	Only polar ligation done due to fast pulse rate.
7	F. 58	Adenoma	+61 +38	12	..	15	85–90	Postoperative auricular fibrillation.
8	F. 30	Exophthalmic	+38	15	..	9	85	See Case 6. Thyroidectomy at this time.
9	F. 34	Adenoma	+30 +26	15	..	10	..	
10	M. 48	Exophthalmic	+27	18	..	15	80–85	
11	F. 35	Adenoma	+12 +18	15	..	12	75–80	
12	F. 43	Adenoma	....	18	..	15	75	
13	F. 42	Adenoma	+42 +31	15	..	13	65–75	
14	M. 42	Exophthalmic	+75	15	..	12	80–85	Postoperative auricular fibrillation. Reaction to intravenous normal saline.
15	F. 28	Adenoma	+27 +27	15	..	13	60–80	
16	F. 48	Adenoma	+15 +30	15	..	14	75	Partially digitalized for control of auricular fibrillation pre-operatively. Fibrillated after operation.
17	F. 31	Adenoma	+26 +21	15	..	14	85	
18	M. 30	Exophthalmic	+54 +63	18	..	15	85	
19	M. 27	Exophthalmic	+19 +27	20	..	22	85–90	
20	F. 38	Adenoma	+32	15	..	14	50–60	
21	F. 24	Adenoma	+22 −5	15	..	10	75	
22	F. 24	Adenoma	+ 8	..	28	22	80–85	
23	F. 28	Adenoma	+41 +14	15	..	17	75	
24	F. 27	Adenoma	+59	..	27	22	75–85	
25	F. 26	Adenoma	+22	..	30	18	75–80	
26	M. 23	Adenoma	+ 9	18	..	15	..	
27	F. 26	Adenoma	+ 8	..	20	30	80–85	

The patients received the sodium amytal in bed while they were still in their rooms and fell to sleep naturally without noticeable excitement or apprehension. When given into the vein it was administered immediately before the operation and from one to one and a half hours prior when given rectally. The drug was prepared fresh in 10 per cent solution by mixing dry crystals with triple distilled water. When the intravenous method of administration is used, considerable circulatory depression is observed if the rate of injection exceeds 100 milligrams per minute. In this series 10 to 20 minutes were allowed for the injection.

Observations of the blood pressure during the intravenous administration of the drug were made in a few cases of this series, and showed a rather constant fall, amounting on the average to 25 millimeters of mercury in the systolic and 10 millimeters in the diastolic readings, during the time of injection. After the injection had been completed, a rise of from 15 to 20 millimeters was usually observed, and in all cases the pressure was maintained at approximately a normal level

throughout the operation. Figure 1 illustrates the different types of reaction which were encountered in our series. Case 2 is the most typical.

Transfer to the operating room was accomplished with the patients in a light sleep and free from excitement.

Nitrous oxide gas and oxygen were used as a supplementary anæsthetic. It was found that relatively low percentages of this gas produced satisfactory anæsthesia. The great majority of cases received from 75 to 85 per cent nitrous oxide, and a few as low as 65 to 75 per cent. With such mixtures, excellent anæsthesia was maintained on these patients and cyanosis was completely eliminated with one exception. This patient (Case 6), a young woman acutely ill with toxic thyroid symptoms, had a double ligation of the superior poles. A slightly larger dose of sodium amytal would have been more effective.

Immediately after the operation the patients began to awake slowly and the effect of the amytal was fortified by small doses of morphine to produce a quiet sleep from which they could be aroused if necessary. When awakened they co-operated in a rational manner. Also there was freedom from nausea and vomiting which is frequently observed in the operating room after operation following nitrous oxide and ethylene anæsthesia. No evidences of postoperative mania or excitement were encountered. Prolonged sleep did not occur after any of these anæsthetics.

The postoperative course in general was good in this series. There were no deaths. The pulse rates were elevated to 130 or 140 in most instances; in only two cases were rates as high as 150 seen. Temperatures varied from 100 to 102.5 degrees, a few were as high as 103 degrees. In one patient a reaction occurred following the intravenous injection of normal salt solution, and during this time a temperature of 108 degrees was reached.

The only complication seen was auricular fibrillation which occurred in 5 cases. All of these were controlled satisfactorily with digitalis.

SUMMARY

In this small series of thyroid cases, we believe that the pre-operative preparation of the patients with comparatively small doses of sodium amytal (seldom exceeding 15 grains) renders the patients free from apprehension of the anæsthetic and the operation. In addition adequate anæsthesia is obtained with smaller amounts of nitrous oxide and a proportionately larger amount of oxygen, thus largely obviating cyanosis. Also the postoperative course of the patients is free from nausea, vomiting, and laryngeal mucus.

Since it is highly desirable to have as much control as possible of the anæsthetic agent, we believe that the intravenous method of administration affords the greatest degree of flexibility when loss of consciousness is desired.

THE EFFECTS OF SODIUM AMYTAL

On Liver Function; the Rate of Secretion and Composition of the Urine; the Reaction, Alkali Reserve, and Concentration of the Blood; and the Body Temperature[1]

WESLEY BOURNE, M.D., C.M., M.Sc., M. BRUGER, M.D., C.M., M.Sc., and
N. B. DREYER, M.A. (Oxon.), M.R.C.S., L.R.C.P., Montreal, Canada
Department of Pharmacology, McGill University

THE therapeutic usefulness of barbituric acid derivatives as hypnotics was first demonstrated by Fischer and v. Mering in 1903. The one under consideration, isoamyl ethyl barbituric acid, commonly called amytal, was first prepared in 1923 (Shonle), and has been used as a laboratory anæsthetic for the past 7 years (5, 10). Recently, Zerfas, McCallum, Shonle, Swanson, Scott, and Clowes have shown that it may also be used as a general anæsthetic in man. Amytal was first employed clinically at Indianapolis (12, 20, 21) and at present is being used in many clinics. Its increasing use, therefore, makes it desirable to know as much as possible concerning its more intimate pharmacological actions. Accordingly, we have investigated the effects of the substance upon the functions of the liver and kidneys, the reaction, alkali reserve, and concentration of the blood, and the body temperature in dog and man.

LIVER FUNCTION

The method employed for testing the function of the liver was that of Rosenthal and White, which depends upon the removal of bromsulphthalein from the blood by the liver. The results are shown in Table I. In the experiments upon dogs the doses of amytal varied from 40 to 60 milligrams per kilogram of body weight. In the first 3 of these the sodium salt was prepared in the laboratory and given intraperitoneally, whereas, with the remaining 10, the drug used was the already prepared salt, administered intravenously. It will be seen that in only two instances was there as much as a 20 per cent retention of dye in the blood 24 hours after amytal; in the majority there was very much less. Normal animals show about 5 per cent dye retention. It will also be seen that there is no evidence of delayed liver damage. In the human cases (done at the Western Division, Montreal General Hospital), in spite of the fact that small quantities of inhalation anæsthetics were used in each, there was no dye retention 24 hours after the administration of 1 gram of amytal.

These results show that so far as hepatic function is concerned, amytal compares well with some of the inhalation anæsthetics. Rosenthal and one of us (2, 14) have compared the effects of chloroform, ether, nitrous oxide, and ethylene on the liver, using the dye method. The action in the case of chloroform is particularly marked. Chloroform impairs liver function for 8 days when given for half an hour and for 6 weeks when administered for 2 hours. When anæsthesia is produced by ether, liver function is only slightly depressed after 24 hours (15 per cent dye retention) and is again normal after 48 hours. Relatively, then, and of practical importance, the harm done by sodium amytal to the liver would seem to be negligible.

RATE OF SECRETION AND COMPOSITION OF THE URINE

Six experiments were conducted on dogs with bladder fistulæ, according to the method of Stehle and Bourne. The urine was collected as it was secreted, urea determined by the method of Stehle and phosphorus and chlorine by the micro-method of Pregl. Table II is an example of the results obtained in the 6 experiments. In four instances 60 milligrams per kilogram and in two 50 milligrams per kilogram of amytal were used. Administration was by vein in all cases but one, in which the drug was given intraperitoneally. It will be seen that anuria does not occur but that there is a very definite degree of oliguria. The quantity of urea excreted per minute by the kidney is lessened, but its

[1]Read by invitation before the Montreal Medico-Chirurgical Society on April 25, 1930.

percentage is increased. Phosphoric acid excretion is always increased, sometimes to a much greater extent than in the protocol given. Variations in chloride excretion are more irregular than in the case of urea, but in general resemble the latter.

Some observations have been made on man at the Western Division of the Montreal General Hospital. The bladder was emptied and washed the evening before operation. The urine passed thereafter was kept and added to that obtained at the next catheterization, just before the administration of the drug. Catheterization was repeated shortly after the operation, and again 24 hours later. It will be seen from Table III, which is a fair example of three such experiments, that the results obtained resemble those with dogs.

It is evident that little or no damage is done to the kidney, for although there is an oliguria and a reduction in the quantities of urea and chlorine excreted, yet there is a percentage increase in these materials, which would imply active kidney function. It will be shown below that sodium amytal produces a blood dilution which would ordinarily be expected to cause an increased urine flow. That the opposite occurs is difficult to explain at this time. The decrease may merely be the result of a lowered blood pressure.

These results are somewhat different from those obtained with ether (18). In ether anæsthesia there is complete anuria or very marked oliguria. Urea and chlorine excretion are so much depressed that in spite of the oliguria the concentrations of these substances also diminish. The increase in phosphoric acid which occurs following both ether and amytal anæsthesia is more marked in the case of the latter and is probably, as in ether anæsthesia, involved in the acidosis now to be described.

TABLE I.—SODIUM AMYTAL ON LIVER FUNCTION

Experiment No.	Dog No.	Dose per kilogram	Route	Time blood was withdrawn following amytal injection	Dye retention
		mgs.		hours	per cent
1	18	50	Intraperitoneally	24	20
				66	− 5
2	18	50	Intraperitoneally	24	20
				42	−10
3	19	50	Intraperitoneally	24	10
				90	10
4	22	40	Intravenously	24	− 5
5	23	40	Intravenously	24	− 5
6	22	50	Intravenously	24	10
				72	15
				168	− 5
7	23	50	Intravenously	24	−10
				72	−10
				168	− 5
8	24	55	Intravenously	25	.....
				66	− 5
9	25	55	Intravenously	25	10
				66	− 5
10	24	60	Intravenously	24	− 5
				72	− 5
11	25	60	Intravenously	24	15
				72	−10
12	22	60	Intravenously	24	− 5
				72	− 5
13	23	60	Intravenously	24	5
				72	− 5

HUMAN

1. Male. 64 kilograms. Appendectomy. 1 gram sodium amytal, some nitrous oxide, and a little ether. Morphine before and after. No dye retention in 24 hours.

2. Male. 68 kilograms. Trephining and curetting humerus. 1 gram sodium amytal, some nitrous oxide, and oxygen. Morphine before and after. No dye retention in 24 hours.

3. Female. Double salpingo-oophorectomy. 1 gram sodium amytal, some nitrous oxide, and a little ether. Morphine before and after. No dye retention in 24 hours.

THE REACTION AND ALKALI RESERVE OF THE BLOOD

The carbon dioxide combining power of the plasma was determined by the method of Van Slyke and Cullen and the hydrogen-ion concentration values by that of Dale and Evans. Charts I and II show the results obtained. It will be seen that following the administration of amytal, the blood bicarbonate increases to a slight extent, except in one instance in which it rose from 39.5 volumes per cent to 53.7 volumes per cent. In this case, however, the dog was markedly anæmic (corpuscle volume 23.9 per cent). In every case following the administration of amytal, the hydrogen-ion concentration of the blood increased, the pH values falling 0.1 to 0.2 unit. This increase in the hydrogen-ion concentration of the blood is maximal about 1 hour after the drug is given, but in one experiment it had not begun to fall again at the sixth hour. Hines, Boyd, and Leese have also recorded a slight increase in the hydrogen-ion concentration of blood in amytal anæsthesia. However, in their experiments

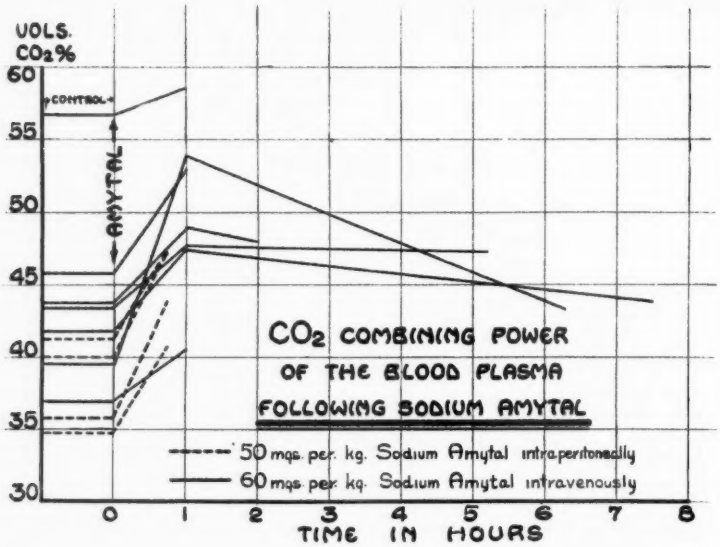


Chart 1.

glucose solution was injected continuously. This may account for the somewhat smaller effects which they observed.

The acidosis accompanying amytal anæsthesia differs from that observed in ether anæsthesia in that the latter is accompanied by a lowered plasma bicarbonate while the former is accompanied by an increased bicarbonate. Some additional factor, therefore, seems to be involved in the acidosis of amytal anæsthesia, which is not present, or at any rate important, in ether anæsthesia. This factor may be the greater respiratory depression produced by amytal. Thus the high carbon dioxide tension of the blood may be compensated in part by a migration of base into the blood. Experiments of Hjort and Taylor indicate that such a migration probably occurs in morphine narcosis in which respiratory depression is also profound. The increase in the hydrogen-ion concentration of the blood is probably due in part to a disturbance in phosphoric acid metabolism as reflected by the increased phosphorus excretion. It is possible that investigation would reveal a concomitant increase of lactic acid in the blood, since the metabolisms of the two are very closely related.

Koehler, Brunquist, and Loevenhart have shown that anoxæmia produces a more marked

TABLE II.—URINALYSIS—BLADDER FISTULA, DOG, 2, WEIGHT 8.6 KILOGRAMS

Time	C.cm. per minute*	Mgms. urea per minute*	Urea per cent	Mgms. phosphorus per minute*	Per cent phosphorus	Mgms. chloride per minute*	Per cent chloride
1:50—2:30*	.562	25.125	4.466	.439	.0780	.184	.0327
2:40—3:40	.167	10.403	6.002	.536	.3097	.068	.0395
3:40—4:40	.160	9.268	5.793	.925	.5784	.040	.0259
8:55—9:55	.140	6.683	4.774	.205	.1467	.236	.1690
(next day) 10:00—11:00†	.057	3.492	6.163	.126	.2226	.033	.0581
2:30—3:30	.080	5.459	6.824	.098	.1229	.092	.1157

*2.31—2.30 injection of 60 mgms. per kilogram sodium amytal intravenously (5.16 c.cm. of a 10 per cent aqueous solution).
†At 11:00 a.m. 200 cubic centimeters of water was given by stomach tube.

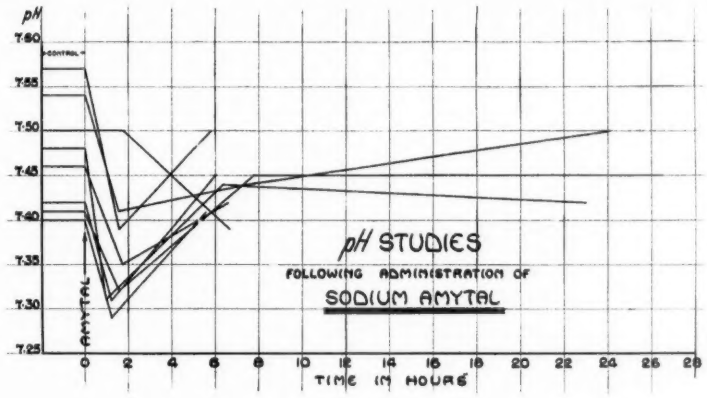


Chart 2.

acidosis than has been observed in any other condition, but we cannot attribute the acidosis in our animals to this factor alone. In every case following the injection of amytal the condition of the dogs was observed closely, and upon the slightest sign of cyanosis, as evidenced by blueness of the tongue, oxygen was given intrapharangeally, a good color being maintained throughout the experiment. We are inclined, therefore, to attribute the acidosis following the administration of amytal to phosphoric acid and possibly to lactic acid as suggested above, anoxæmia being a small and perhaps insignificant factor.

BLOOD CONCENTRATION

Blood solids were determined by weighing a small amount of blood, as drawn, before and after drying to constant weight at 110 degrees C. Corpuscle volume was determined by centrifuging oxalated blood in graduated tubes. Twelve experiments were done (Table IV) and with but a single exception, the blood showed a definite degree of dilution after the injection of sodium amytal, the maximum hydræmia occurring about 1 hour after the administration of the drug. The contrast with ether, which produces a marked blood concentration, is striking. Hines, Boyd, and Leese have reported increases in hæmoglobin in amytal anæsthesia, even when glucose solution was being administered. We are at a loss to explain this.

TABLE III.—URINALYSIS, CASE 2, MISS M., AGED 22 YEARS—APPENDECTOMY, RETROCÆCAL, DIFFICULT

Sample	Mgms. urea per minute*	Mgms. phosphorus per minute*	Mgms. chloride per minute*	Remarks
Control period (12 hour sample)*	5.466	.4649	.791	
Anæsthetic period (4 hour sample)	3.792	.3382	1.049	Supplemented by some ether. No morphine or atropine.
Post-anæsthetic period (24 hour sample)	9.055	.7752	1.005	Morphine gr. 1/6 Some water but no food.

* 1.5 grams sodium amytal in 10 per cent aqueous solution intravenously.

Frequently in the course of other work in this laboratory in which luminal was used as a general anæsthetic in dogs, it was noticed that the spleen often increased enormously in size, due, possibly, to an accumulation of corpuscles within it. It is possible that the same occurs with amytal (both drugs being closely related) thus decreasing the solid constituents of the circulating blood. In other words, the hydræmia following sodium amytal, far from implying an increase in blood volume, may actually imply a decrease. There may be some connection between such a decrease in blood volume and the oliguria noted earlier, but to explain the latter satisfactorily is impossible without further investigation.

TABLE IV

Blood solids per cent	
Control	20.57
1 hour after amytal	19.52
2 hours after amytal	20.54
Control	20.75
1 hour after amytal	18.40
2 hours after amytal	18.95
Control	18.24
1 hour after amytal	13.94
Corpuscle volume per cent	
Control	47.8
1 hour after amytal	37.6
2 hours after amytal	36.9
Control	42.33
1⅓ hours after amytal	34.35
Control	33.07
1 hour after amytal	26.77
Control	46.92
1 hour after amytal	35.15
Control	41.66
1 hour after amytal	36.13
Control	23.9
1 hour after amytal	14.8
6⅓ hours after amytal	20.9
Control	41.6
1 hour after amytal	43.2
6¼ hours after amytal	42.0
Control	38.3
1 hour after amytal	33.3
7½ hours after amytal	35.2
Control	37.7
1 hour after amytal	31.8
5 hours after amytal	41.6
23 hours after amytal	42.5
Rectal temperature degrees centigrade	
Control	39.5
15 minutes after amytal	39.4
1 hour after amytal	39.3
2 hours after amytal	39.2
Control	39.1
15 minutes after amytal	38.6
1 hour after amytal	37.6

BODY TEMPERATURE

Deuel, Chambers, and Milhorat have shown that the administration of amytal produces a fall in body temperature from 2 to 3 degrees. During the course of our work, we have taken the rectal temperatures of our animals before and after amytal (Table IV) and can confirm this. Obviously, owing to the general quiescence of the animal and the decreased metabolism, a fall in body temperature is rather to be expected.

SUMMARY

Sodium amytal has very little action upon liver function as determined by the bromsulphthalein test, comparing favorably with ether in this respect. It depresses urine formation much less than ether. The combined carbon dioxide and the hydrogen-ion concentration of the blood are increased, the former change being due possibly to the depressed respiration and the latter to disturbed phosphoric-lactic acid metabolism. Hydræmia and a fall of body temperature also occur.

BIBLIOGRAPHY

1. Bourne, Wesley, and Stehle, R. L. J. Am. M. Ass., 1924, lxxxiii, 117.
2. Bourne, Wesley. Canadian M. Ass. J., 1927, xvii, 1030.
3. Dale, H. H., and Evans, C. L. J. Physiol., 1920, liv, 167.
4. Deuel, H. J., Jr., Chambers, W. H., and Milhorat, A. T. J. Biol. Chem., 1926, lxix, 249.
5. Edwards, D. J., and Page, J. H. Am. J. Physiol., 1924, lxix, 177.
6. Fischer, E., and v. Mering, J. Therap. d. Gegenw., 1903, iii,
7. Hines, H. M., Boyd, J. D., and Leese, C. E. Am. J. Physiol., 1926, lxxvi, 293.
8. Hjort, A. M., and Taylor, J. A. J. Pharmacol. Exper. Therap., 1919, xiii, 407.
9. Koehler, A. E., Brunquist, E. H., and Loevenhart, A. S. J. Biol. Chem., 1925, lxiv, 313.
10. Page, J. H. J. Lab. & Clin. M., 1923, ix, 194.
11. Pregl. Die Quant. Organ. Microanalyse. Berlin, 1923.
12. Robbins, A. R., McCallum, J. T. C., Mendenhall, A. M., and Zerfas, L. G. Am. J. Obst. & Gynec., 1929, xviii, 406.
13. Rosenthal, S. M., and White, E. C. J. Pharmacol. Exper. Therap., 1924, xxiv, 265.
14. Rosenthal, S. M., and Bourne, Wesley. J. Am. M. Ass., 1928, xc, 377.
15. Shonle, H. A., and Moment, A. J. Am. Chem. Soc., 1923, xlv, 243.
16. Stehle, R. L. J. Biol. Chem., 1922, li, 89.
17. Stehle, R. L., and Bourne, Wesley. J. Physiol., 1925, lx, 229.
18. Idem. Arch. Int. Med., 1928, xlii, 248.
19. Van Slyke, D. D., and Cullen, G. E. J. Biol. Chem., 1917, xxx, 289.
20. Zerfas L. G., McCallum, J. T. C., Shonle, H. A., Swanson, E. E., Scott, J. T., and Clowes, G. H. A. Proc. Soc. Exper. Biol. & Med., 1929, xxvi, 399.
21. Zerfas, L. G., and McCallum, J. T. C. J. Indiana M. Ass., 1929, xxii, 47.

TRIBROMETHYL ALCOHOL (AVERTIN) ANÆSTHESIA[1]

CHARLES S. WHITE, M.D., F.A.C.S., AND JOSEPH KREISELMAN, M.D., WASHINGTON

PRESENT day surgery requires a wide range of anæsthetic agents. In certain surgical procedures and in the presence of various pathological conditions, the desirability of general anæsthesia by rectal administration is quite evident. In 1923, Willstaetter and Duisberg succeeded in synthetizing tribromethyl alcohol (known commercially as avertin), which is well adapted for this purpose. Over 150,000 cases of tribromethyl alcohol anæsthesia have been reported in the European literature. From a review of these records and from our own experience, it seems to us that we have acquired a valuable new anæsthetic for use in certain cases.

In tribromethyl alcohol we have an anæsthetic which produces unconsciousness in a most satisfactory manner. When combined with light gas anæsthesia, the relaxation is usually adequate. The duration of the anæsthesia is sufficiently prolonged, and no unpleasant postoperative complications have been observed.

Without attempting comparisons with other anæsthetics, we believe tribromethyl alcohol is entitled to a very high rating in respect to safety. Deaths have been reported under its use, but these were due almost entirely to improper administration and overdosage, both of which errors are now being eliminated by riper experience. While the relatively small number of our cases does not permit us to speak authoritatively, from our general experience with gas, ether, and their combinations, we do not hesitate to express the opinion that tribromethyl alcohol is equally as safe.

Although ether anæsthesia produces unconsciousness, it apparently protects none of the brain cells against exhaustion from the trauma of operation. The anæsthetic gases are said to produce about one-fourth the exhaustion after equal trauma, according to Gwathmey. It is impossible to estimate the amount of damage inflicted by the psychic shock in some patients, particularly children, immediately preceding and during the induction of anæsthesia. With preliminary morphine medication, the proper dosage of tribromethyl alcohol, light gas anæsthesia, and infiltration with novocain, perhaps the most complete brain block is produced.

DESCRIPTION

Tribromethyl alcohol is a white crystalline substance, soluble in water at 40 degrees C. (104 degrees F.) up to 3.5 per cent. As the powder dissolves rather slowly in water, tribromethyl alcohol is usually employed in the more convenient form of a concentrated solution in amylene hydrate, containing 1 gram in each cubic centimeter. If solutions are heated above 45 degrees C. (113 degrees F.), tribromethyl alcohol decomposes by the liberation of hydrobromic acid and the formation of dibromacetaldehyde (a toxic irritant to the intestinal mucosa).

PREPARATION AND ADMINISTRATION

The evening before operation a cleansing enema should be given. Special measures to empty the intestines on the day of operation should be avoided, as fluid in the bowel may retard absorption. Before the operation, morphine may be given as in preparation for gas anæsthesia.

The amount of tribromethyl alcohol to be administered is calculated according to the weight of the patient. Our dosage has varied from 75 milligrams to 120 milligrams per kilogram of body weight, the average being 100 milligrams per kilogram. In estimating the dosage, the weight of the patient is taken as the index, and the dosage is then varied according to the experience of the anæsthetist. Routine calculation of the dosage on the basis of body weight should not be practiced. It has been found that children and young adults require relatively larger doses than older persons. On the other hand, the obese, the debilitated, the aged, and patients with impaired elimination should receive less than the average dose estimated by weight.

[1]Read before the Medical Society of the District of Columbia, December 21, 1929.

In preparing solutions, accuracy in every particular is essential. We have employed a 3 per cent solution, but a 2.5 per cent solution is now generally preferred. It is important that distilled water be used, and that the solution should not be subjected to a temperature higher than 40 degrees C. (104 degrees F.). Otherwise, tribromethyl alcohol is decomposed with the formation of hydrobromic acid and dibromacetaldehyde, which are very irritating to the intestine. Neither should the solution be allowed to cool, since this may cause crystallization of the drug, and thus render the injection ineffective. The finished tribromethyl alcohol solution should always be tested before it is administered by adding to 5 cubic centimeters a few drops of a 1:1000 aqueous solution of Congo-red. The resulting color should be a clear orange red, without any bluish or violet tint (the latter indicating decomposition.)

One-half hour before operation, the solution of tribromethyl alcohol is introduced into the rectum by means of a small rectal tube. The tube is removed and the patient is allowed to remain undisturbed until sleep occurs.

ACTION

When injected into the rectum, tribromethyl alcohol is absorbed by the intestinal mucosa more rapidly than the water in which it is dissolved. The absorption is fairly rapid, totaling 80 per cent in the first 20 minutes, and 95 per cent within the first 2 hours. No local irritation of the rectal mucosa has been observed from the use of a properly prepared and tested solution. During anæsthesia the concentration of tribromethyl alcohol in the blood is 6 to 9 milligrams per cent.

Detoxication of tribromethyl alcohol occurs in the liver through the formation of a compound with glycuronic acid, the resulting product being eliminated by the kidneys. Straub recovered 81 per cent of the drug in this combination from the urine within 48 hours, and Parsons obtained 72 per cent in the same period. Slight traces of bromine have been found in the perspiration, but not in the fæces or in the expired air.

Respiration is superficial in tribromethyl alcohol anæsthesia, but in cases of dyspnœa, the respiratory center is not materially affected. The heart is evidently not influenced by the average anæsthetic dose. The pulse rate is practically normal, and there is usually little change in blood pressure, although occasionally a fall up to 20 millimeters occurs. (We observed 2 cases of marked fall in blood pressure without apparent shock.)

In from 3 to 10 minutes after the rectal administration of tribromethyl alcohol solution, sleep occurs without a preliminary stage of excitement. The patient retains no recollections of the induction of anæsthesia. Return to consciousness is almost always uneventful, as the awakening from a natural sleep. In 7 per cent of our cases a generalized tremor was noted during induction, or before the return of consciousness. This occurred only during light anæsthesia. There was no nausea or vomiting in 78 per cent of cases. Catheterization was required in 6 per cent of the series, once following hæmorrhoidectomy and twice after pelvic operations. For 25 per cent of the operations (mostly minor procedures) no supplemental anæsthesia was required. Patients withstood even hæmorrhoidectomy and perineal operations well without supplemental anæsthesia, and were remarkably free from postoperative pain.

ANÆSTHESIA

The outstanding feature which makes tribromethyl alcohol a remarkable agent is the ease with which anæsthesia is produced. No anæsthetic with which we are familiar approaches it in this respect. It is now possible to produce unconsciousness without the patient being aware that an anæsthetic is being given. The patient falls asleep in 3 to 10 minutes without mental or physical excitation, and usually recalls the experience only vaguely, and then as a pleasant one. Thus, surgery has been divorced from much of its terror. Tribromethyl alcohol is a boon to the excitable and apprehensive patient, and especially to children. It has filled a great void in pediatric surgery. A child is given the small tribromethyl alcohol enema in bed without any disturbance, and in a few minutes falls asleep without excitement and without being aware of the impending operation.

The initial stage of tribromethyl alcohol anæsthesia usually lasts from 1½ to 2 hours. The relaxation under tribromethyl alcohol is one is generally sufficient for all minor operations and sometimes even such major ones as amputation and hernioplasty. In abdominal work, however, we prefer supplemental anæsthesia with ethylene (or nitrous oxide) and oxygen, or with novocain, locally. The necessity of complete relaxation cannot be over-emphasized because much postoperative shock, ileus, and even infection can be ascribed to an unyielding abdomen. Furthermore, more time is consumed and more trauma inflicted when the abdomen is rigid, thus contributing to postoperative morbidity.

We have had but one failure, and that was due to improper preparation of the patient. In this case the rectum was distended with fluid when tribromethyl alcohol was administered, and the entire rectal contents were expelled. We have not found it necessary to stop the anæsthetic or to resuscitate a patient in our series. On the other hand, we have been impressed by the freedom from cyanosis (the patient being watched carefully to prevent mechanical obstruction), sweating, and marked fall in blood pressure, which are common with other anæsthetics.

POSTOPERATIVE STAGE

As a rule, patients leave the table dry, pink, and warm. The wet pallid skin that is occasionally seen after ether, spinal, or even local anæsthesia is entirely absent.

At the end of the initial stage of the anæsthesia the patient reacts, and may complain of pain, thirst, or hunger; upon being relieved with morphine, he falls asleep again for several hours. During this period there is no nausea, vomiting, or motor restlessness; there is less postoperative distention and less abdominal pain than after other general anæsthetics. Patients who previously had 7 or 8 anæsthetics stated that they experienced much less discomfort with tribromethyl alcohol and preferred this type of anæsthesia.

Hæmorrhage during or immediately after operation has never been a source of concern.

Not a single patient has complained of rectal irritation, nor have the nurses in attendance recorded sanguineous or mucous discharge from the bowel. Two patients have had three successive tribromethyl alcohol anæsthesias within 7 to 10 days without untoward effects.

There has been no unusual delay in healing of the wounds, and the patients, generally, have left the hospital on the appointed day.

Comparative changes in avertin anæsthesia in operative cases:

	No. of cases	Average change after operation
Red blood cells	20	−122,400
White blood cells	19	+6,242
Hæmoglobin	20	−1.3
Clotting time	5	No change
Blood sugar	10	+3 mg.
Non-protein nitrogen	9	+4.5
Chlorides	8	−5.3
Carbon dioxide	4	−8
Pulse rate	20	+5
Respiratory rate	20	+3.15
Blood pressure		
Systolic	20	+4.5
Diastolic	20	−3.4

In our series there was nothing noteworthy in the urinary findings. A trace of acetone was found in 5 cases, but only in 1 specimen from each patient. (Gwathmey reports this finding in two ether series, in 88.5 and 26 per cent respectively.)

The blood examinations were about 24 hours after the anæsthesia, while the records of the pulse and blood pressure were taken at the beginning and end of anæsthesia.

In only 22 per cent was nausea or vomiting present. This is a very much lower percentage than we have had in ether and gas anæsthesia.

The remote effects of tribromethyl alcohol, if such there are, can scarcely be intelligently discussed, as only about 7 months have elapsed since we initiated its use; but if the toxicity is serious, we should expect to find such evidence in damage to the liver or kidneys, as they are the chief organs involved in the elimination of the drug. We are not cognizant of a reliable test of liver function, but we can approximate kidney damage by the urine examination. Recent examination of the urine of some of the earliest cases failed to show any essential change in the urine.

CONTRA-INDICATIONS

Avertin anæsthesia is contra-indicated in (1) severe diseases of the liver and kidneys

(tribromethyl alcohol is detoxified in the liver and it is nearly all excreted through the kidneys); (2) advanced pulmonary tuberculosis; (3) ulcerative diseases of the rectum and colon; (4) extreme cachexia; and (5) acidosis.

In dehydrated and elderly patients tribromethyl alcohol should be used with great care. It is especially well tolerated in hyperthyroidism. In the presence of hypothyroidism it has been suggested that the delayed elimination might be hastened by the administration of thyroxin.

AUTHORS' SERIES

We have employed tribromethyl alcohol in over 500 cases, but only the first 100 cases have been used as the basis of this report. The major operations were for the following conditions: appendicitis, 41; hernia, 14; goiter, 4; gall-bladder or gall-duct disease, 12; intestinal obstruction or neoplasm, 4; uterine tumor, 4; gangrene of the leg, 2. The remainder (19) were minor surgical procedures.

The dosage has been conservative, no effort having been made to complete anæsthesia with tribromethyl alcohol alone, as this was deemed unwise and not without danger. Marked cyanosis has not occurred in any case. This is attributed to the fact that we used a light dosage, the patients have been watched carefully, and a clear air-way has been maintained at all times.

CONCLUSIONS

Anæsthesia can be induced with tribromethyl alcohol in an almost ideal manner. Convalescence is more comfortable and there is less nausea and vomiting than with other general anæsthetics. In our opinion tribromethyl alcohol has a definite place among the anæsthetic agents now available.

A review of the foreign literature leaves one confused if an effort is made to evaluate tribromethyl alcohol as a general anæsthetic. When used alone for deep anæsthesia, its use is attended with danger, but when used as a basic anæsthetic, it is probably one of the safest agents for anæsthesia. We feel that the use of tribromethyl alcohol with gas or novocain, combines in the highest degree, excellence and safety in anæsthesia.

We stress the fact that no anæsthetic is absolutely safe, and the same precautions should surround the administration of tribromethyl alcohol that attend the use of any other anæsthetic. Carelessness will be penalized by morbidity and mortality. A conscientious regard for the safety of the patient demands the services of a well trained anæsthetist in every major operation.

BIBLIOGRAPHY

1. Amersbach, K. Rectal anesthesia and its use in otorhinolaryngology. Schmerz, 1928, i, 212–214.
2. Blomfield, Joseph, et al. Discussion on avertin anæsthesia. Brit. M. J., 1929, ii, 856–857.
3. Blomfield, Joseph, and Shipway, F. E. Lancet Lond., 1929, i, pp. 546–549.
4. Borchardt, Moritz. Rectal anesthesia with avertin. Deutsche med. Wchnschr., 1927, liii, 909–911.
5. Butzengeiger, O. Clinical experience with avertin (E 107). Deutsche med. Wchnschr., 1927, liii, 712–713.
6. Idem. Technic and results of avertin anesthesia. Zentralbl. f. Chir., 1929, lvi, 204–208.
7. Dressen, Josef. Discussion on avertin anesthesia. Zentralbl. f. Chir., 1928, lv, 3204–3205.
8. Idem. Use of avertin in chronic renal disease. Zentralbl. f. Chir., 1929, lvi, 2202–2204.
9. Eichholtz, F. Rectal anesthesia with E 107. Klin. Wchnschr., 1929, vi, 1163.
10. Idem. Rectal anesthesia with avertin (E 107). Deutsche med. Wchnschr., 1927, liii, 710–712.
11. Idem. Rectal anesthesia with E 107. Klin. Wchnschr., 1927, vi, 1163.
12. Idem. Narcotic action of tribromethanol. Deutsche med. Wchnschr., 1929, lv, 1537–1538.
13. Elsbach, K. Rectal anesthesia with avertin amylene hydrate solution. Ztschr. f. Hals-, Nasen-, u. Ohrenheilk., 1929, xxiii, 290–295.
14. Endoh, C. Reaction of tribromethylalcohol in animals. Biochem. Ztschr., 1924, clii, 276–280.
15. Gossman, J. R. Dangers of avertin anesthesia. Zentralbl. f. Chir., 1928, lv, 395–399.
16. Grossman, Hans. Rectal anesthesia with solution of avertin in amylhydrate. Zentralbl f. Gynaek., 1929, 780–783.
17. Guttman, J. R. Rectal anesthesia with tribromethylalcohol. Ann. Surg., 1929, xc, 407–414.
18. Haas, W. Rectal narcosis with E-107. Deutsche med. Wchnschr., 1927, liii, 1375–1377. Abstracted in Brit. J. Anæsth., 1928, v, 191.
19. Hammerschlag. Avertin anesthesia. Deutsche med. Wchnschr., 1928, iv, 562.
20. Heinicke, E. Avertin und lebersihadigung. (Avertin and lesions of the liver.) Zentralbl. f. Chir., Leipz., 1929, lvi, 3147–3153.
21. Herzberg, M. H. Pharmacological experiments with avertin in rectal anesthesia. Deutsche med. Wchnschr., 1928, i, 1044.
22. Hillebrand, H. Favorable results in 180 cases of avertin anesthesia. Ztschr. f. aerztl. Fortbild., 1928, xxv, 652–655.
23. Hornung, R. Rectal anesthesia with avertin to dull labor pains. Muenchen. med. Wchnschr., 1928, lxxv, 595–596.

4. HUGHES, BASIL. Progress in anesthesia from the surgeon's standpoint. Brit. M. J., 1929, May, 897.
5. KILLIAN, HANS. Pharmacological action of E 107. Zentralbl. f. Chir., 1927, liv, 1997–2003.
6. Idem. Results of rectal avertin anesthesia. Narkose u. Anaesth., 1928, i, 16–42.
7. Idem. Experimental researches on avertin. Narkose u. Anaesth., 1928, i, 119–131.
8. Idem. Avertin and phrenectomy. Zentralbl. f. Chir., 1928, lv, 2626–2630.
9. Idem. Avertin—rectal anesthesia; results to date. Brit. J. Anaesth., 1928, v, 168–177.
10. Ibid. 1928–1929, vi, 48–52.
11. Idem. Recent progress in anesthetics in Germany; with special reference to avertin and pernocton. Current Res. Anaesth. & Anal., 1929, viii, 24–33.
12. KIRSCHNER, M. Rectal anesthesia with E 107. Muenchen. med. Wchnschr., 1927, lxxiv, 917.
13. Idem. Intravenous injections for general anesthesia. Chirurg, 1929, i, 673–682.
14. KOHLER, HERMANN. Rectal anesthesia. Deutsche med. Wchnschr., 1928, liv, 178–180.
15. Idem. Death during avertin anesthesia reported by Schrodl. Zentralbl. f. Chir., 1928, lv, 1806.
16. Idem. Discussion of avertin anesthesia. Zentralbl. f. Chir., 1928, lv, 3011–3014.
17. Idem. Avertin anesthesia in gynecological operations. Zentralbl. f. Gynaek., 1929, liii, 2209–2214.
18. KOLLER, T. Avertin anesthesia in phrenico-exersis. Zentralbl. f. Chir., 1928, lv, 2498–2500.
19. KRENTER, E. Rectal anesthesia with avertin; 650 cases. Zentralbl. f. Chir., 1927, liv, 3074–3076.
20. LAWEN, A. Avertin in the treatment of tetanus. Zentralbl. f. Chir., 1927, liv, 2370–2377.
21. Idem. Symptomatic treatment of tetanus with avertin. Zentralbl. f. Chir., 1928, lv, 194–201.
22. LEVIT, J. Experiences with avertin anesthesia. Rozhledy v chir. a gynaek., 1928, No. 4. Abstracted in Zentralbl. f. Gynaek., 1929, liii, 316.
23. LOEWE, S. Inhalation anesthesia or an operative soporific? Klin. Wchnschr., 1927, vi, 1848–1850.
24. MARTIN, B. General anesthesia with avertin. Arch. f. klin. Chir., 1928, clii, 670–675.
25. Idem. Avertin as general anesthesia. Deutsche med. Wchnschr., 1928, liv, 1154–1156.
26. Idem. Present-day knowledge of avertin and its practical application. Deutsche med. Wchnschr., 1928, liv, 2068–2070, 2110–2121.
27. Idem. The modifications of avertin anesthesia. Zentralbl. f. Chir., 1929, lv, 72–74.
28. MARTIN, E. Avertin in midwifery. Monatschr. f. Geburtsh. u. Gynaek., 1927, lxxvi, 241–243.
29. Idem. Twilight sleep with avertin in obstetrics—summary of results in 800 cases. Deutsche med. Wchnschr., 1928, liv, 180–181.
30. MARTIN, E. L. Twilight sleep with avertin. Med. Welt, 1928, ii, 518.
51. MUHSAM, EDWARD. Rectal anesthesia with avertin. Schmerz, 1928, ii, 106–129.
52. NIGST, P. F. Results from avertin anesthesia up to the present. Schweiz. med. Wchnschr., 1929, lix, 281–289.
53. NORDMANN, O. Rectal anesthesia with E 107. Zentralbl. f. Chir., 1927, liv, 1055–1058.
54. Idem. Rectal anesthesia with avertin; replies to questionnaires. Med. Klin., 1928, xxiv, 529–533.
55. POLANO, O. Rectal anesthesia with E 107 in gynecology. Muenchen. med. Wchnschr., 1927, liv, 630–631.
56. PRIBRAM, B. O. On avertin anesthesia. Zentralbl. f. Chir., 1929, lvi, 1164–1168.
57. Idem. Die Stenerungsnioglichkeit der Avertinarkose Durch Thyroxin. (On the possibility of controlling the avertin narcosis with thyroxin.) Zentralbl. f. Chir., Leipz., 1929, lvi, 3138–3142.
58. RUGE, E. Avertin anesthesia; favorable results. Med. Welt, 1928, ii, 873–875.
59. SCHRANK, H. Effect of avertin anesthesia on circulation. Zentralbl. f. Chir., 1928, lv, 3205–3207.
60. SCHULZE, WALTER. Rectal anesthesia with avertin amyl hydrate solution. Deutsche med. Wchnschr., 1927, liv, 1928.
61. SCHWALBE, J. Present status of avertin anesthesia. Questionnaire. Deutsche med. Wchnschr., 1927, liii, 2064–2069.
62. SEIFFERT, J. One thousand avertin anesthesias. Zentralbl. f. Chir., 1929, lvi, 283–290.
63. SIEVERS, RODERICK. Avertin (E 107) anesthesia in children. Deutsche med. Wchnschr., 1927, liii, 1253–1255.
64. Idem. Technic of general avertin anesthesia for children. Zentralbl. f. Chir., 1929, lvi, 194–204.
65. STRAUB, W. Absorption and dosage of avertin in rectal anesthesia. Muenchen. med. Wchnschr., 1928, lxxiv, 593–595.
66. Idem. Excretion of avertin by the organism, and its secondary effects when used in rectal anesthesia. Muenchen. med. Wchnschr., 1928, lxxv, 1279–1281.
67. Idem. Clinical and pharmacological notes on avertin anesthesia. Klin. Wchnschr., 1928, viii, 2346.
68. UNGER, ERNST, and HENSZ, HEINZ. Rectal anesthesia with E 107. Muenchen. med. Wchnschr., 1927, lxxiv, 567.
69. Idem. Rectal anesthesia with E 107. Med. Klin., 1927, xxiii, 634.
70. UNGER, ERNST, and MAY, H. Electrocardiographic investigations during anesthesia with avertin. Zentralbl. f. Chir., 1927, liv, 3272–3273.
71. WILHELM, T. Ueber Befahrungen mit Avertin in der Praxis des Allgemeinen Krankenhauses. Zentralbl. f. Chir., Leipz., 1929, lvi, 3145–3147.
72. WOLF, A. Zur Technik der Rektalem Avertinarkose bei Mastdarm, und Dickdarm Operationen. Zentralbl. f. Chir., Leipz., 1929, lvi, 3142–3145.

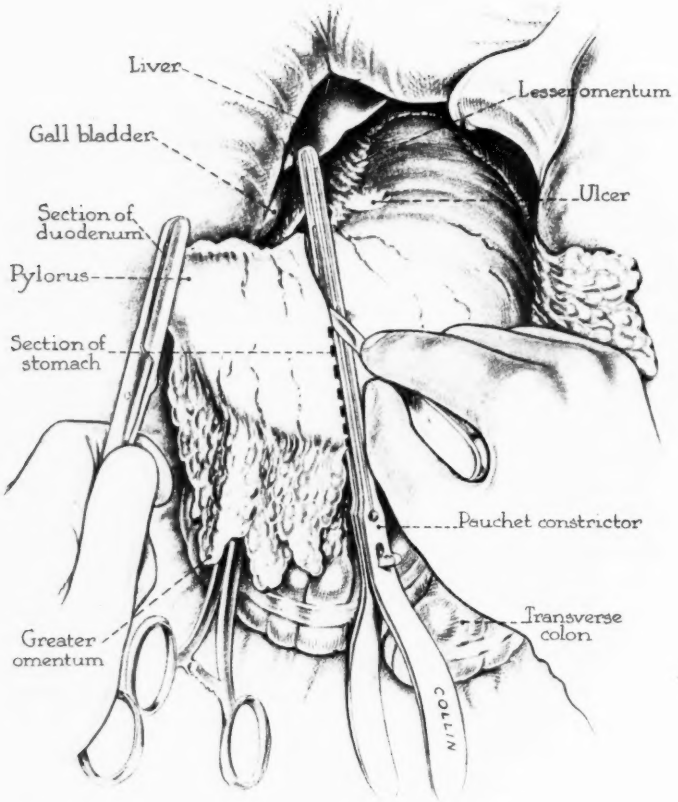


Fig. 20. The stomach is sectioned vertically from the lesser to the greater curvature, *below the ulcer*. Here a constrictor has been placed on the stomach, but that is not necessary. It is sufficient to place one forceps at the top and one at the bottom of the line of section and cut from one to the other.

Surgical Treatment of Ulcers of the Superior Third of the Stomach.—Victor Pauchet and Gabriel Luquet

CLINICAL SURGERY

FROM ST. MICHEL HOSPITAL, PARIS

SURGICAL TREATMENT OF ULCERS OF THE SUPERIOR THIRD OF THE STOMACH (GROOVE RESECTION)

DR. VICTOR PAUCHET, PARIS, FRANCE
Surgeon, St. Michel Hospital
AND
DR. GABRIEL LUQUET
Assistant Surgeon, St. Michel Hospital

BY ulcers of the superior third of the stomach we mean any ulcer between the boundary of the middle and upper thirds of the stomach and the cardia. Nineteen per cent of gastric ulcers are included in this class. Such ulcers are often perforating and are particularly frequent in men between 50 and 60 years of age. They are many times associated with ulcers lower in the stomach or in the duodenum. Because of the anatomical form of this special variety of ulcer, surgical treatment is not always easy and the most ardent advocates of resection hesitate to undertake it under such bad conditions. Resection by the usual method is difficult because of the height of the focus, and because it is not easy to establish an anastomosis beneath the diaphragm on such a small gastric stump (Fig. 1). That is why we propose a method of resection which avoids this difficulty. We have been using the technique to be described for several years and so far it has given good results.

The operation is a groove resection which fulfills the double indication of all stomach resections: (1) excision of the ulcer and adjacent parts and (2) removal of the secreting part of the stomach. In addition it leaves a gastric stump sufficiently large to prevent too great functional disturbance and by transforming the stomach into a tube it re-establishes the gastro-intestinal tract.

We would like to emphasize the value of this method. It should be used systematically and not as a last resort in cases in which the ulcer is situated high. We are using this technique more and more even in cases of ulcers which are situated in the middle third of the lesser curvature and in which the stomach is not readily movable.

TECHNIQUE

After section of the duodenum and liberation of the stomach, the latter is divided along a line which starts from the greater curvature at the boundary between the antrum and the body and passes upward in the direction of the lesser curvature. At about the place where the upper third meets the lower two-thirds, the direction of the resection is changed so that the line of incision passes to the left side of the cardia, describing a curve which encircles the ulcer and the tissue immediately adjacent to it. The resected part of the stomach includes, as has been stated, the pylorus, the antrum pylori, and the lesser curvature of the stomach on which the ulcer is located (Figs. 2 and 3).

The operation may be done in one stage by making the entire incision at one time but if it is hard to free the stomach or if the boundaries of the ulcer are not very distinct, it is easier to use two stages. In the first stage the stomach is sectioned completely along the line joining the greater and lesser curvatures, while in the second stage the curved line is sectioned (Figs. 20 and 21).

The details of the operation are as follows:

Incision of the wall. A median incision extending from the ensiform process to the umbilicus is used. If it is necessary, and it often will be, a branch incision may be made perpendicular and to the left, which gives very free access to the region. We do not advise chondral or costal resections which become infected easily and result in weak walls (Figs. 4 and 5).

Exploration and liberation of the stomach. The posterior surface of the stomach is reached either by pushing the insertion of the great omentum from the greater curvature with compresses or

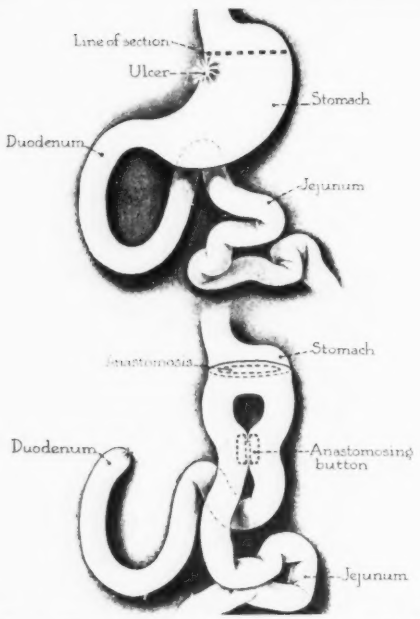


Fig. 1. The operation, subtotal gastrectomy with long loop anastomosis and complementary jejunojejunostomy, is not to be advised because it is too hard to perform.

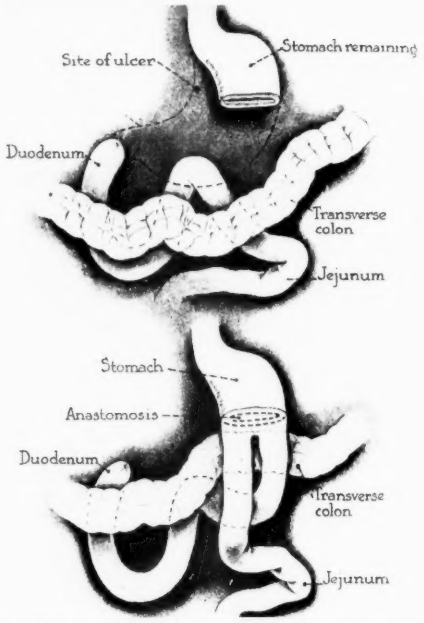


Fig. 3. Operation of choice—groove gastrectomy, which is completed by a precolic Pólya anastomosis with a short loop.

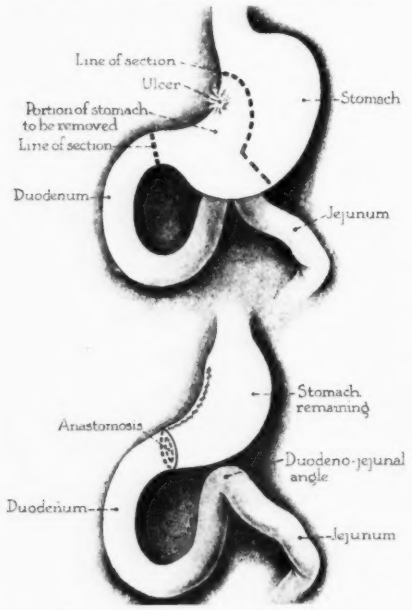


Fig. 2. Groove resection of same type of ulcer, completed by a Péan's anastomosis.

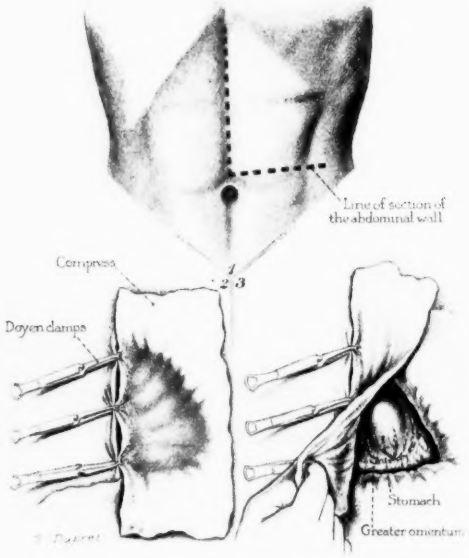


Fig. 4. L incision turned to the left. Fixation of the operative fields.

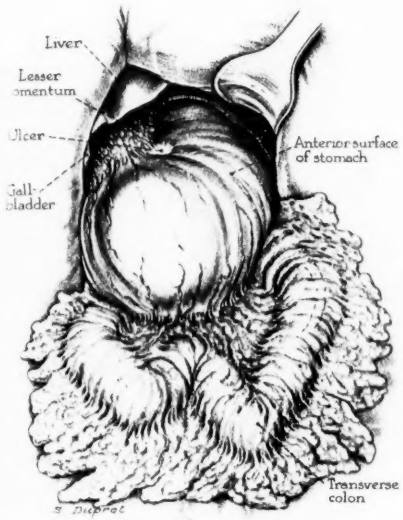


Fig. 5. Exploration of the anterior surface of the stomach. The operator can see the ulcer which is situated high on the lesser curvature.

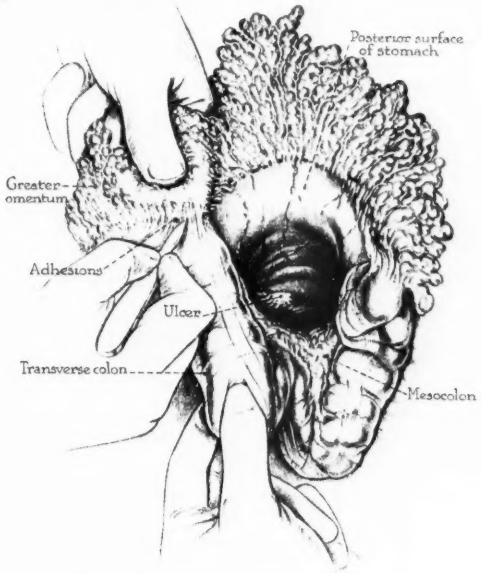


Fig. 6. After detachment of the colon and omentum the ulcer can be seen on the posterior surface.

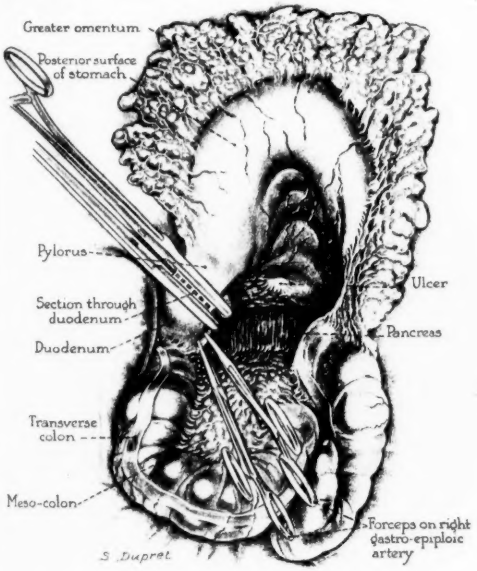


Fig. 7. The liberated duodenum is sectioned between two forceps following the dotted line. Hæmostasis of the pyloric artery (labeled right gastro-epiploic).

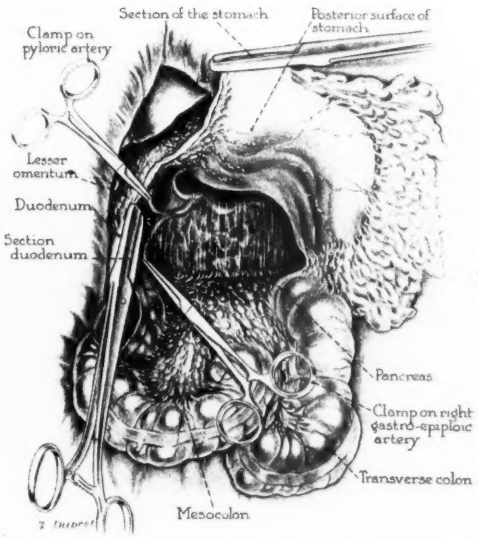


Fig. 8. The duodenum has been cut and the lesser omentum sectioned. The three arteries to be ligated are: right gastro-epiploic, pyloric, and coronary of stomach.

Fig. 9.

Fig. 10.

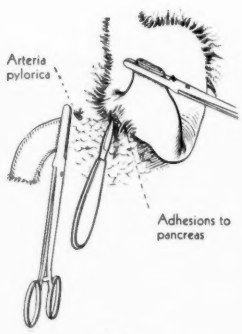


Fig. 11.

Fig. 9. *Search for the coronary artery.* The left index finger is inserted between the lesser curvature and the pulsating cord. *1*, Stomach near the lesser curvature; *2*, sectioned small omentum; *3*, coronary artery seen through the transparent mesocolon.

Fig. 10. *Ligation of the coronary artery.* The suture carrier gliding along the index finger perforates the lesser omentum. The thread is properly placed.

Fig. 11. Dissection of the perforating ulcer at the pancreas.

by detaching the omentum from the colon by section. The latter method seems preferable to us because it is more elegant and more anatomical: it separates and sections rather than tears. Moreover, it is bloodless and does not require the many ligations that are necessary after other methods; also stumps of omentum that may become more or less infected and cause adhesions are eliminated (Fig. 6).

At this stage the ulcer is examined more thoroughly, its exact situation is determined, and its size and the extent and kind of adhesions to the adjacent planes are noted.

Section of the duodenum. Even in the operation of gastropyloric resection, it has always seemed to us preferable to section the duodenum first, but in cases in which the ulcer is situated high this is absolutely necessary in order to liberate and section the stomach; there is no choice. The attachments of the omentum to the upper and lower borders of the duodenum are divided with a bistoury or scissors, particularly the upper part

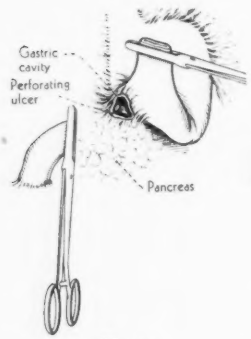


Fig. 12.

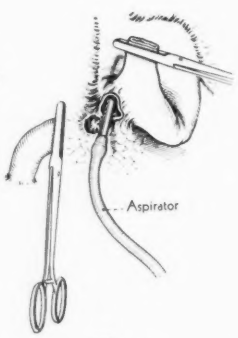


Fig. 13.

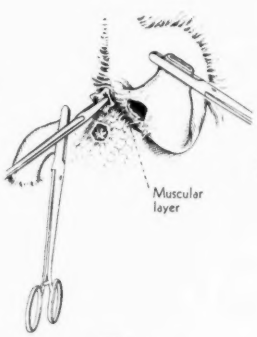


Fig. 14.

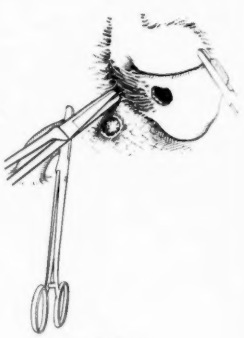


Fig. 15.

Fig. 12. In the course of the dissection the stomach is opened at the site of the ulcer. This opening is unavoidable due to the fact that there is a loss of stomach substance.

Fig. 13. The contents of the stomach are evacuated through the opening by means of an electrical aspirator.

The base of the ulcer can be seen on the anterior surface of the pancreas.

Fig. 14. The stomach is dissected free by means of a tampon which is mounted on forceps.

Fig. 15. As the adhesions become firmer scissors are taken to section them.

Fig. 16. The stomach is held by three forceps and the incision, which permits of economical resection combined with removal of the ulcer, is traced on the mucous membrane of the anterior surface.

Fig. 17. The anterior surface is sectioned with scissors. A Chaput's forceps is placed at the angle where the incision turns.

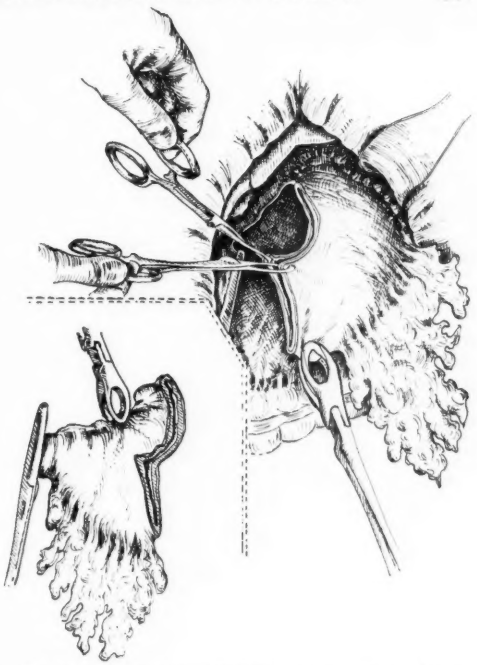


Fig. 18. Appearance of stomach when resection is completed and of the part that has been removed.

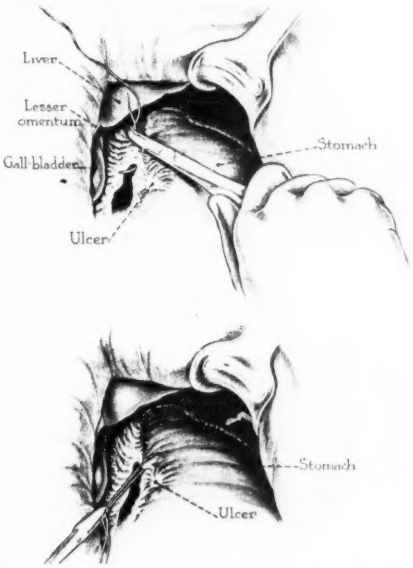


Fig. 19. How to place the mooring suture to prevent retraction of the stump of the stomach toward the concavity of the diaphragm.

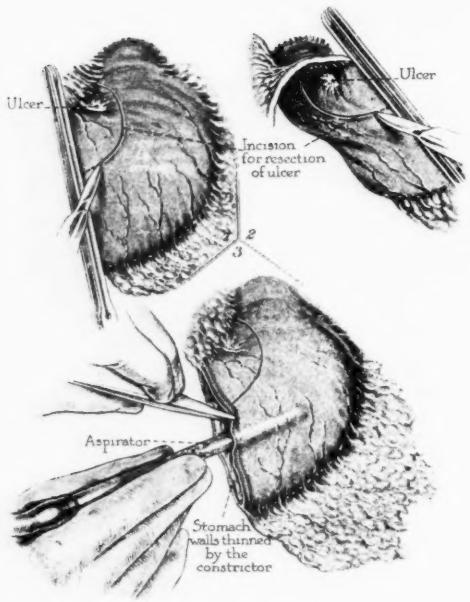


Fig. 21. With a bistoury, the operator traces the limits of the resection, first on the anterior and then on the posterior surface of the stomach. The excision includes the ulcer and the adjacent indurated tissue. Below, necessary aspiration of the stomach contents. No clamp can be applied.

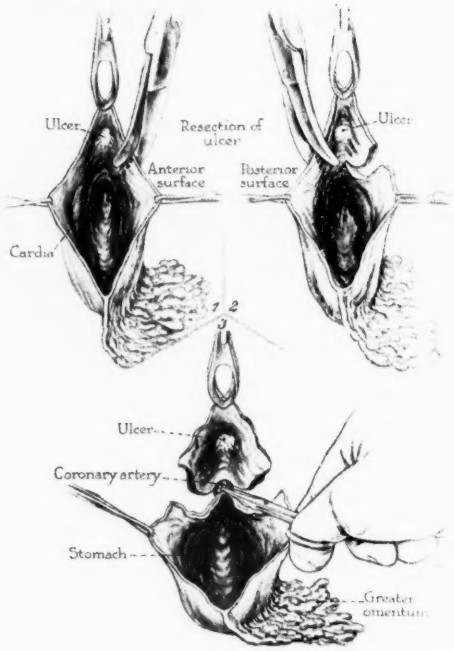


Fig. 22. Excision of the ulcer of the lesser curvature under the control of vision. Thanks to the mooring suture held by an assistant there is no retraction. In 3 the coronary artery is being constricted with forceps as it has not been possible to ligate it in advance.

of the right border of the great omentum, which is cut between two ligatures, care being used not to injure the serous covering of the intestine. The vessels that bleed are caught with forceps, particularly the pyloric artery. Then two strong forceps are placed parallel on the juxtapyloric part of the duodenum and the duodenum is cut between them. The cut surfaces are painted with iodine (Figs. 7 and 8). The sectioned stump is covered with compresses and laid aside for the moment.

Section of the lesser omentum, liberation of the lesser curvature, and ligation of the coronary artery. If the ulcer has not perforated we proceed as follows: Along the upper border of the stomach and a little above it the gastrohepatic omentum is sectioned, the line of incision passing toward the cardia. This step generally does not cause any hæmorrhage; but if bleeding does occur the cut vessels are caught with forceps and ligated. The lesser curvature is thus liberated. If there are adhesions to the deep layers the point of a bistoury or scissors which grazes the wall of the stomach is used. When the incision reaches above the ulcer the coronary artery is ligated. This ligature should be placed as high as possible, near the cœliac trunk. The lesser curvature is grasped between the thumb and index finger of the left hand; a few millimeters from the border of the stomach a pulsating cord will be felt; the index finger is passed from behind forward in the little space between the two (Fig. 9); a suture carrier is passed along the index finger and perforates the meso; the suture is in place and need only be tied (Fig. 10). The meso is then cut between the ligature and the ulcer, the incision passing horizontally to the right border of the stomach; the meso should be completely sectioned but the serous covering of the stomach should not be incised. If this stage is properly done the hand suddenly feels the stomach "give"; the lesser curvature seems to unroll as if a cord that held it up had been cut. Care must be taken not to tear the stomach by pulling on it violently as all the region around the ulcer is very friable

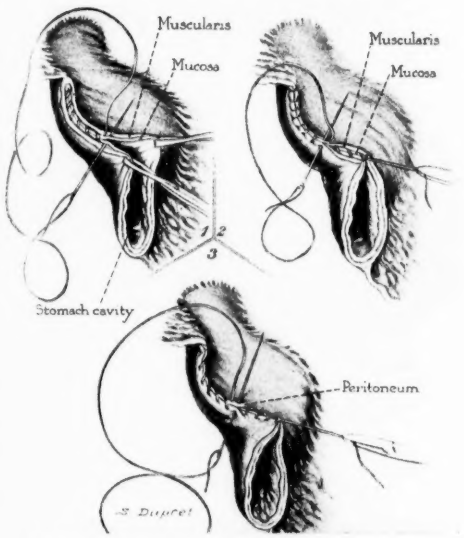


Fig. 23. The remaining part of the stomach is transformed into a groove which will become a tube by reconstruction of the lesser curvature. This reconstruction is carried out in three layers as the walls of the stomach are thick. Two layers may be enough.

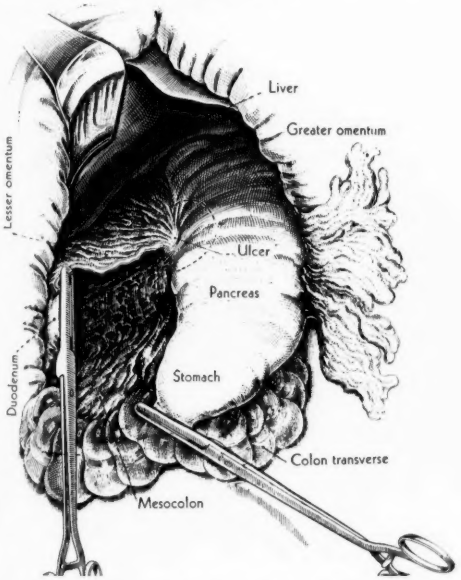


Fig. 24. The stomach, after section of the duodenum, is freed to the region of the ulcer. The line of gastric section, which must encircle the ulcer is marked with a dotted line.

Fig. 25. The dissection of the ulcer penetrating into the pancreas opens the stomach. Aspiration of the gastric contents.

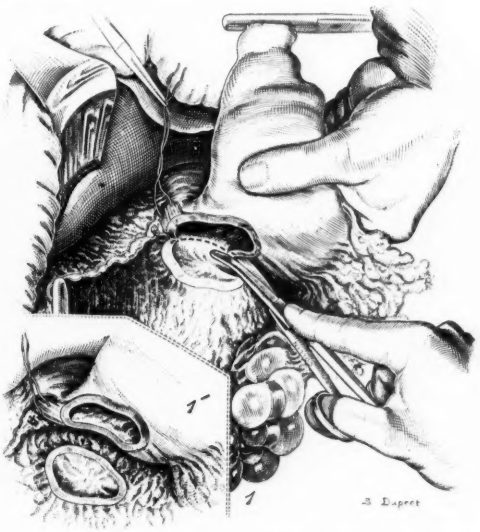


Fig. 26. The upper boundary of the ulcer is freed with scissors. A mooring suture has been passed above it in the lesser curvature and the coronary artery has been ligated.

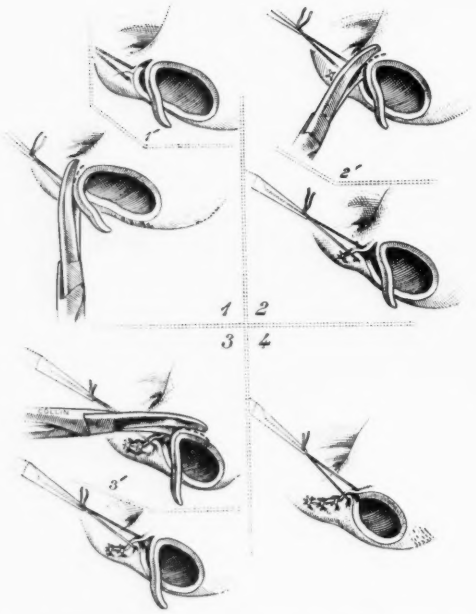


Fig. 27. The removal of the ulcer is completed by excision with scissors of callous part of stomach adjacent to it. As the section is made, catgut sutures are placed so as to reconstruct the lesser curvature immediately.

Fig. 28. The diseased stomach tissues are removed and the lesser curvature reconstructed. The operator then traces on the serous and muscle layers of the wall the posterior suture line of the body of the stomach.

If the ulcer has perforated into the pancreas, which is true in the majority of cases, we proceed as follows: The adhesions if any are present are freed. They are generally quite loose and unite the upper surface of the stomach with the lower surface of the liver. The stomach is held by traction on the forceps which closes it and stretched, and with short cuts of the scissors the lesser omentum is sectioned above the lesser curvature until the diseased zone is reached (Fig. 11). The scissors are laid aside and with a tampon mounted on a pair of forceps, the adhesions are freed methodically to the right and left of the ulcer and below it. In this way more ground is gained than might be supposed and the perforating region of the ulcer is demarcated well. A cutting instrument is then taken—bistoury or scissors—and the adhesions that have resisted the tampon are freed. This process is outlined until the place where the stomach is adherent to the pancreas is reached. Short incisions are then made with the scissors along the surface of the gland until the stomach cavity is opened. This necessarily happens because there is loss of substance (Fig. 12). The tube of the electrical aspirator, which is absolutely essential in this operation, is introduced through the opening and the stomach is emptied (Fig. 13). The surgeon or his aid passes a finger under the stomach to encircle and stretch it, and the upper outline of the ulcer is liberated. The part that remains in the pancreas, as it forms a part of the latter, is painted with iodine to await attention later. After the stomach has been removed, bits of stomach wall that remain may be removed with a curette or the point of a bistoury (Figs. 14 and 15).

Section of the lesser omentum is finished and the coronary artery is ligated as before. Sometimes the indurated tissue around the ulcer extends up very high and the ligation of the vessels has to be put off until the following stage when the upper part of the stomach is sectioned.

If the ulcer has perforated into the liver, operation is generally easier, the work is done in front of the organ, and the surgeon can see what he is doing.

After having freed the adhesions with a mounted tampon, the liver and stomach are sca-

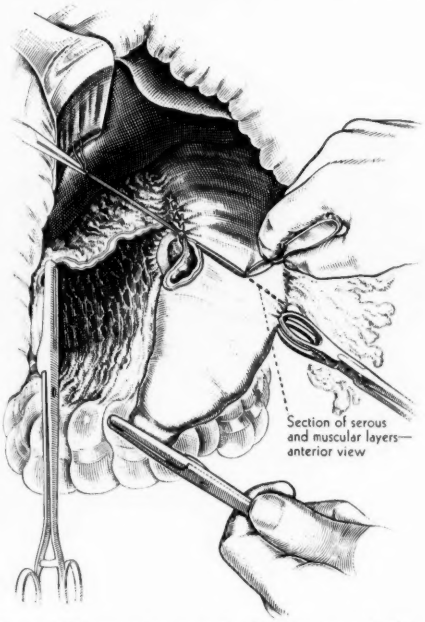


Fig. 29. The operator traces in the same way the future line of section of the anterior surface.

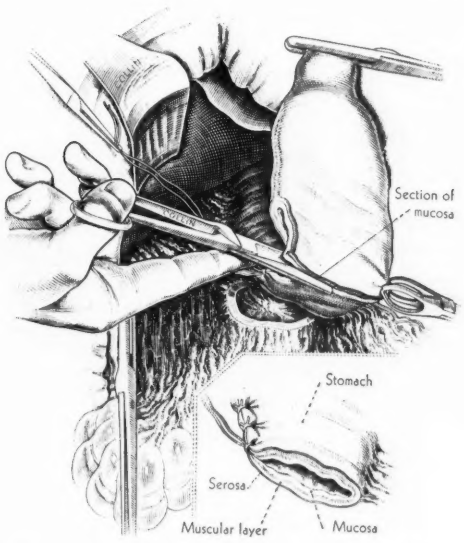


Fig. 30. Section of the body of the stomach following the tracing.

rated with a cutting instrument. Care must be taken not to tear the liver, for this would cause regrettable hæmorrhage necessitating tamponing that would be fatal to the adjacent sutures. Here too it is better to leave a little of the ulcer adherent to the liver after having painted it with iodine.

Section of the stomach. As already stated the stomach may be sectioned in one or two stages.

Section in one stage. After the stomach is completely freed of its attachments, the surgeon chooses the place where the vertical part of the section is to be made near the junction of the antrum and the body. He puts a Lane's hook on the greater curvature at this place and a second one on the lesser curvature at a corresponding point below the ulcer. An assistant pulls these two forceps in opposite directions to stretch the stomach in width, and the operator pulls on the forceps which closes the pylorus and stretches it in length. He traces the incision on the serous membrane with the tip of a bistoury; it starts to the right of the lower forceps which should be left on the part of the stomach that is to remain, and passes up to the upper forceps, but at the junction of the lower two-thirds with the upper third it changes its direction, and passes upward and to the left to encircle the ulcerated region; it should pass distinctly outside the limits of the latter and then run obliquely to the lesser curvature above, near the point where the coronary artery has been ligated (Fig. 16).

A suture should now be placed to prevent the later rise of the stump of the stomach, so that the sutures can be placed on the lesser curvature without danger. This "mooring suture" which is of strong catgut, is passed with a curved needle very high up between the œsophagus and the upper end of the ulcer. It is not tied but a forceps is placed on it and the forceps is handed to an assistant who holds it until the reconstruction of the lesser curvature is finished (Fig. 19).

After having marked the line of section in this way, the stomach is still held stretched and the anterior wall is sectioned in the vertical part of the line and then in the curved part. As soon as this latter part of the section is started, a Chaput's forceps should be placed on the angle where the turn is made, to serve as a tractor and guide (Fig. 17). The same thing is done on the posterior surface; it is sectioned parallel to the anterior opening and a Chaput's forceps is placed at the junction of the two parts of the incision. When the section has been done in this way, the stomach is made up of two parts, floating above, united below by the greater curvature, that is, it is transformed into a veritable "groove" (Fig. 18).

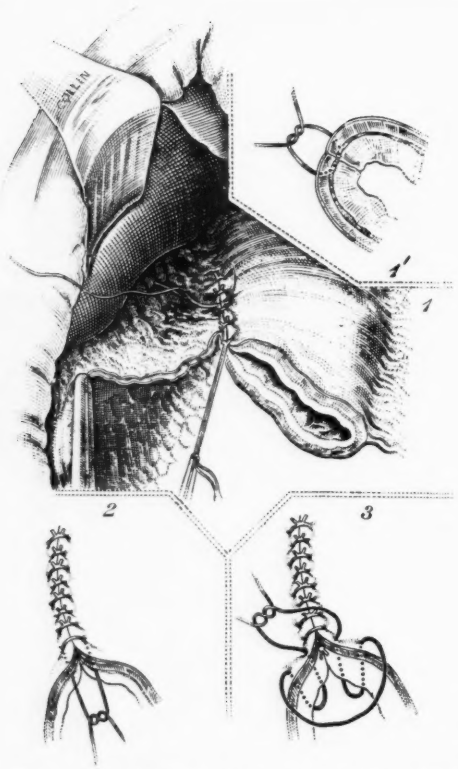


Fig. 31. The suture of the lesser curvature is completed by a layer of interrupted seroserous sutures. *2* and *3*, The way in which the last sutures are placed.

It is obvious that as soon as the stomach is opened at the beginning of the vertical section, the aspirator must be introduced to empty the stomach so that the operation can be continued dry.

Section in two stages is advisable in very difficult cases and those in which the ulcer is very high up. The forceps are arranged as for section in one stage but throughout their width from one forceps to the other, the anterior wall is cut and then the posterior wall to the right of the forceps. This gets rid of the entire antrum of the pylorus (Fig. 20). A Chaput's forceps is placed on each one of these sections at the starting point of the curved incision which is to circumscribe the ulcer. Excision is done with curved scissors. At this stage the surgeon may ligate the coronary if this has not been done before (Figs. 21 and 22).

The appearance of the stomach is then the same as when the technique for the one stage

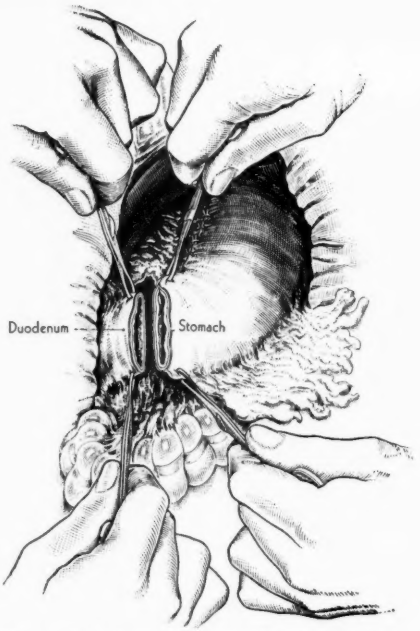


Fig. 32. The stomach, whose caliber is reduced to that of the duodenum, is placed in contact with the latter in order to make a Péan anastomosis (Billroth I).

operation is used. These different sections may be made with the electrical bistoury, which is hæmostatic and sterilizing.

Reconstruction of the lesser curvature is generally easy enough, except perhaps high up near the cardia. As an assistant pulls on the two Chaput forceps at the angle so as to stretch the upper edges, the operator sutures the whole tract uniting the two curved sections and continuing the sutures to the angle of the wound. Fine catgut is used and the suturing is done from above downward; from the difficult to the easy. A seroserous suture is now made over this total suture and the gastric groove is transformed into a tube (Fig. 23).

If it is too difficult to place these continuous sutures in the high part of the incision some interrupted sutures may be used in both layers (total and seroserous). But in either case great care must be used, particularly in the higher part of the wound, to prevent secondary disunion.

There are cases in which a perforating ulcer very high on a small, retracted stomach and the surgeon may fear difficulty in reconstructing the lesser curvature with small gastric flaps disappearing under the diaphragm. If the stomach is not

very large it may be desirable to make as economic a resection as possible in the ulcer region to avoid retraction which would disturb function later. In that case a third method may be used, derived from the two preceding ones, in which the order of the stages is inverted.

The operator proceeds by liberating the greater curvature, sectioning the duodenum, and liberating the lesser curvature up to the region of the ulcer (Fig. 24). He then dissects the perforating ulcer with bistoury and scissors and the stomach cavity is thus opened (Fig. 25). With the field now in full view he excises the lesion of the walls to its boundary and the corresponding part of the lesser curvature (Fig. 26). The lesser curvature is reconstructed while a solid hold can still be had on the non-resected stomach (Fig. 27) and only when this reconstruction is completed is the resection terminated by doing the vertical section of the body of the stomach (Figs. 28, 29, 30, and 31).

In short, in this method the curved area encircling the ulcer is resected first and the vertical gastropyloric section is done last.

Obviously the method or combination of methods used should be selected according to the type of lesion and the choice of the operator. When the resection is finished, the stomach is decreased in width and resembles the intestine more or less in form. The remaining stages are like those in the ordinary resection.

Re-establishment of the gastro-intestinal tract. If the duodenum is large it can be sutured end-to-end to the stomach to make a Péan anastomosis (Billroth I, Fig. 32).

If the duodenum does not lend itself to a Péan anastomosis it should be closed and a terminolateral implantation made of the stomach into the jejunum (Pólya) either with a short loop or with a long transmesocolic or precolic loop. In this case it is never necessary to decrease the cross section of the stomach; its mouth is not too large and the whole of it can be used. This is the method that we use most frequently (Fig. 2).

The stomach may be closed completely and a laterolateral gastro-enterostomy performed (Billroth II). We have never tried this method.

Closure of the wall of the abdomen. This can be done in one or several layers, following the usual method and according to the preference of each operator.

RESULTS

In the beginning in ulcers of the superior third of the stomach we practiced either conservative operations or high subtotal resections.

The former gave us, in 5 cases, 1 death and 2 revisions necessitated by lack of improvement, or 20 per cent mortality and 50 per cent bad results.

The second method was used in 23 cases with 6 deaths, a mortality of 26 per cent.

In the 6 years that we have been using groove resection we have had 7 deaths in 44 cases or 15 per cent, a greatly decreased mortality—2 deaths from failure of the opening to function, 1 from pulmonary complications, 1 from peritonitis caused by the breaking down of the sutures, 3 from unknown causes in patients with multiple ulcers which, as is known, make the operative prognosis bad.

As to late results, we have been able to reexamine 22 patients treated by groove resection. In 17 of the cases the results were very good, in 4 cases good, and in 1 case mediocre. All these patients were able to resume a normal life quickly and to stop adhering to a strict diet.

In conclusion we would say that groove resection is an operation which seems to produce cures and is attended with less risk than are the so-called "conservative" operations.

FROM THE SURGICAL CLINIC OF PROFESSOR VON HABERER

THE BILLROTH I RESECTION OF THE STOMACH

DR. K. FRIEDBACHER, DUESSELDORF, GERMANY
Exchange Resident Surgeon from the University of Wisconsin

THERE are two reasons which prompt this writing: The article by Dr. V. Orator published in the September, 1928, number of SURGERY, GYNECOLOGY AND OBSTETRICS leaves one with an incorrect conception of the von Haberer technique and it is the wish of both Haberer and Orator that this misconception be corrected; secondly, alterations have been made in the procedure which considerably improve the operation.

It is the aim of this paper to describe the usual resection, as indicated in duodenal ulcer, omitting those phases which are peculiar to the case and which each operator must clarify for himself.

One of two anæsthetics, either deep ether or splanchnic, is administered and the peritoneal cavity is opened through a midline incision from ensiform to umbilicus. Accurate hæmostasis of the abdominal wall and peritoneum is insisted upon. Gauze gloves are worn over the usual rubber ones to afford better traction.

The stomach is examined and the decision for or against resection is made. Unless there is a very definite indication, e.g., duodenal, gastric, or peptico-jejunal ulcer, carcinoma, or a poorly tolerated gastro-enterostomy, the gastrectomy is not performed. Palpable glands in the lesser omentum or along the greater curvature are important aids in making a diagnosis. In peptico-jejunal ulcer the enlarged glands in the mesentery of the jejunal loop are of equal value in assisting the surgeon to reach a conclusion.

Before continuing with the steps of the resection, we will give a brief résumé of the arterial supply to the stomach.

The cœliac artery divides into three branches:

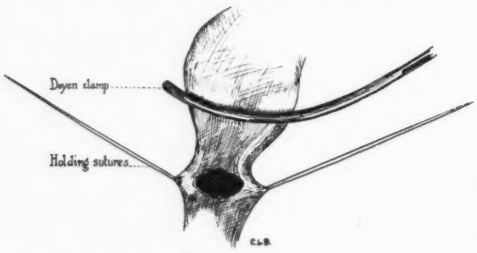


Fig. 1. Position of Doyen clamp and holding sutures.

left gastric, splenic, and hepatic. The left gastric rises upward to the left and enters the gastro-hepatic ligament just below the cardia. It distributes branches to the œsophagus and cardia while the main vessel continues along the lesser curvature to anastomose with the right gastric artery.

From the hepatic artery, the right gastric and the gastro-duodenal arteries are derived.

The right gastric leaves the hepatic just above the pylorus and runs in the gastrohepatic ligament to anastomose with the left gastric artery.

The gastroduodenal artery leaves the hepatic artery below the right gastric, runs posterior to the beginning of the duodenum, and lies directly on the pancreas. It divides into the pancreatico-duodenal and right gastro-epiploic arteries. The former follows the medial surface of the duodenum and the latter runs along the greater curvature where it anastomoses with the left gastro-epiploic artery.

About 3 or 4 centimeters from the spleen, the splenic artery gives off the left gastro-epiploic artery which enters the greater omentum, follows the greater curvature, and anastomoses with the right gastro-epiploic artery.

The preparation of the stomach is begun by ligating and dividing the right gastric artery close to the pylorus. The lateral wall of the duodenum is freed to about 1 centimeter below the ulcer. As a rule the gastrohepatic ligament is divided up to and including the left gastric artery. Through the opening thus created the left hand is passed behind the stomach and firmly grasps the latter so as to place the greater curvature under tension. In a similar manner the vessels in the gastrocolic ligament are ligated and severed. Generally the preparation of the greater curvature begins with division of the left gastro-epiploic artery and is concluded by ligating and dividing the right gastro-epiploic and some branches of the pancreaticoduodenal arteries.

The posterior duodenal wall can now be studied. If necessary the pancreas is bluntly dissected away for a short distance to make certain a posterior lying ulcer does not exist. In most cases where the pancreas can easily be pushed off, the posterior ulcer is not present.

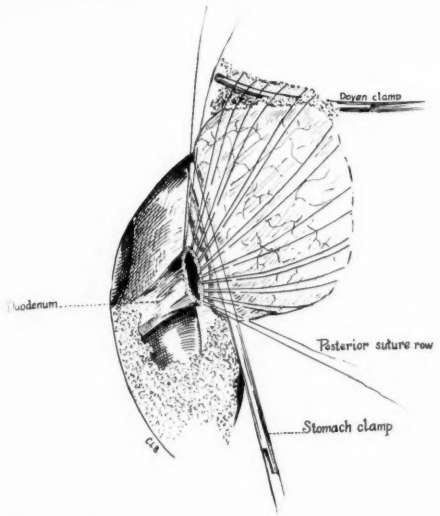


Fig. 2. The posterior row of interrupted sutures in position.

Holding sutures are placed on the lateral and medial sides of the duodenum immediately below the anteriorly lying ulcer (Fig. 1). A Doyen clamp is fastened just proximal to the pylorus, the peritoneal cavity is protected with sponges, and the anterior duodenal wall is cut through with the cautery (Fig. 1). While the holding sutures are held under tension the operator inserts a sponge into the duodenum to prevent its contents from escaping. The inner surface of the posterior wall of the duodenum is then examined under direct vision (Fig. 1). When a clamp is used on the duodenum one is very likely not to see the posteriorly lying ulcer and this, in the opinion of Haberer, is the chief cause of so called recurrent duodenal ulcers after Billroth I operations. Having carefully excluded the posterior lesion, the remainder of the duodenal wall is divided with the electric cautery.

The Doyen clamp is removed, a sponge is placed over the open pylorus, and the Doyen clamp is replaced so as to secure the sponge (Fig. 2). The stomach is then lifted up, drawn to the patient's left, and the Haberer clamp adjusted at the upper resection level (Fig. 2) which is the point where the left gastric and right gastro-epiploic arteries have been severed. The stomach and duodenum are brought into close apposition and the end-to-end anastomosis begun.

The posterior row of interrupted linen sutures is placed in the following sequence: both corners

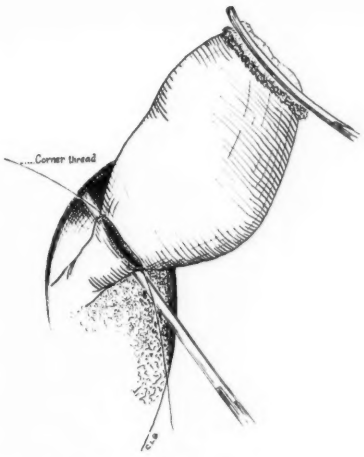


Fig. 3. The two corner threads are held in clamps.

to replace the holding threads, the middle, and then the intervening ones (Fig. 2). The threads are tied in the same sequence in which they were laid but not until all have been placed. The two corner threads are held in clamps and the rest cut off (Fig. 3).

The serosa and muscular layer of the posterior stomach wall are divided by an incision parallel to and about one-half centimeter above the previously laid suture row (Fig. 4). This procedure

Fig. 4. Division of serosa and muscular layer of the posterior stomach wall.

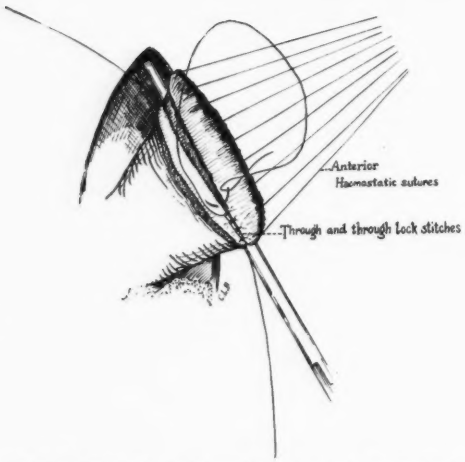


Fig. 5. Through-and-through lock stitch secures posterior wall.

clearly exposes the vessels of the stomach wall which are ligated by interrupted catgut suture ligatures (Fig. 4). These stitches not only have a hæmostatic value but they also reef the stomach making its lumen approach that of the duodenum. A similar incision is made on the anterior wall and the vessels suture-ligatured in a like manner. One leaves the anterior flap longer to facilitate making the anastomosis. The second Doyen is placed

Fig. 6. Operation completed.

distal to these stitches; the suture ligatures having been left long are put under tension, and the stomach is removed with the cautery.

The posterior row of hæmostatic sutures are cut and a through-and-through lock stitch further secures the posterior wall (Fig. 5). Upon reaching the corner one cuts the anterior hæmostatic sutures and continues with the lock stitch until the two lumina are united. Von Haberer makes no attempt to invert the mucosa with this stitch. The anterior wall is completed by placing Lembert serosal sutures so as completely to cover the locked suture row. It is the usual procedure to lay the middle and two end sutures before removing the stomach clamp. The end-result gives one an anastomosis of about two fingers' capacity and the stomach rests on the duodenum "Wie der Pilz am Stiel" (Fig. 6).

The abdominal wall is united in layers.

OPERATIVE MEASURES IN THE TREATMENT OF AFFECTIONS OF THE LUMBOSACRAL AND SACRO-ILIAC ARTICULATION

WILLIS C. CAMPBELL, M.D., F.A.C.S., MEMPHIS, TENNESSEE

CONSERVATIVE measures alone are indicated in a majority of cases with affections of the sacro-iliac and lumbosacral articulations, but in a small percentage symptoms persist in spite of all known remedies, such as eradication of foci, physiotherapy, and various orthopedic procedures. However, affections in this region are so common that even this small percentage means that a large number of patients are not relieved, and the problem thus becomes a serious one from an industrial standpoint.

In cases in which tuberculosis is a causative agent, fusion operations have been routinely employed for the past 15 or more years, but only in recent years have these measures become commonly used in the presence of non-tuberculous affections. Since 1916, however, the author has used fusion operations not only in selected cases of non-tuberculous origin, but has gradually increased the scope of the procedure as experience has demonstrated its value.

Low-back pain is too intricate a problem to discuss briefly, except in a very superficial manner. The syndrome in non-tuberculous affections may be instigated by a variety of causative agents which may be divided into those in which the site of the disease is in the spine and pelvic articulations and in those in which the pain is referred from pathological involvement of organs not connected with the spine. The causative agents which involve the articulations are (a) infection, (b) trauma, (c) postural defects, and (d) congenital anomalies; those external to the spinal column are (a) affections of the pelvic and abdominal organs, (b) affections of the spinal cord, and (c) intestinal stasis or toxæmia.

The second group, or those in which the pathology is external to the spine, must be excluded in making the diagnosis. We are concerned only with those in which the symptoms are due to local affections of the lumbosacral and sacro-iliac articulations.

Differentiation must also be made when possible of the exact site of pathology, whether in the articular process of the lumbosacral region, the intervertebral disc, the intervertebral foramina, or in the sacro-iliac articulations. There are three main articulations to consider—the sacro-iliac and the lumbosacral articulations, any two, or all three, of which may be involved. Differentiation can usually be accomplished by a careful routine physical examination, but not in every instance, as in analogous affections of joints. The examination must be systematic and careful in order to differentiate between lumbosacral lesions and those of the sacro-iliac joints. The examination should be made with the patient in three positions —standing, sitting, and lying. When the patient is standing, muscular rigidity is more pronounced and the characteristic attitude is more apparent. Motion is also restricted to a greater degree when the patient is in this position. Differentiation of involvement of the sacro-iliac joint is made by the following signs: A characteristic sign noted in the examination of many patients with involvement of the sacro-iliac joint is brought out by asking the patient to bend forward. Motion up to a certain point may be free and painless but beyond this flexion causes pain and the spine deviates from the midline, usually toward the affected side. When the patient is in the sitting position tension of the hamstring muscles on the pelvis is relaxed and forward bending is somewhat freer than in the standing position. In the recumbent position passive movements of the spine may be carried out to practically the normal range. Localized points of tenderness may be demonstrated by pressure over the sacro-iliac joints, the insertion of the ligaments, or over the sciatic nerve at its exit through the sciatic notch of the pelvis. With the patient on his back the affected leg is raised with the knee extended. If pain is present on this manipulation, the Kernig sign for meningitis is positive. As pointed out by Goldthwait, this sign is often present in affections of the spinal column. The exact time of the occurrence of pain is a valuable point in the differentiation of lumbosacral and sacro-iliac involvement. One hand is placed under the lumbar spine, the other flexes the hip; if pain is experienced before motion is detected in the lumbar spine, sacro-iliac involvement is indicated. If the patient does not complain of pain until there is movement in the lumbar spine, the affection is in all probability in the lumbosacral joint. Compression of the iliac crest is also a valuable diagnostic sign. The patient lies on the affected side and the examiner presses downward over the opposite iliac crest, and if the sacro-iliac joint is affected, pain is felt on firm pressure. A variation of this sign, though not so valuable, is direct backward pressure over the pubic bone.

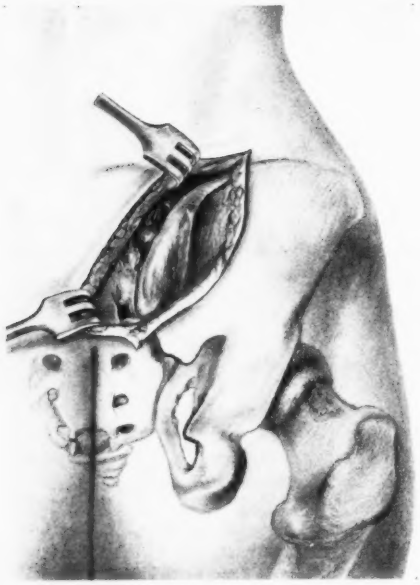


Fig. 1. Incision for extra-articular fusion of the sacro-iliac joint, exposing outer half of posterior surface of sacrum and posterior half of crest of ilium.

Gaenslen has recently described a diagnostic maneuver which he believes is useful in differentiation between lumbosacral affections and between right and left sided sacro-iliac lesions. The patient, lying supine, flexes one knee and hip acutely. The patient is then brought well to the side of the table and the opposite thigh is slowly hyperextended by the examiner with gradually increased force. The hyperextension of the hip exerts a rotating force on the corresponding half of the pelvis in the sagittal plane through the transverse axis of the sacro-iliac joint. The pull is made on the ilium through the Y-ligament and the muscles attached to the anterior superior and anterior inferior spines. As a result of the impaired ligamentous support on the affected side, this rotating force causes abnormal mobility accompanied by pain, either local or referred, in the region of the sacro-iliac joint on the side of the lesion. If the lumbosacral articulation is involved, this maneuver does not cause pain. In addition, in affections of the lumbosacral joint the pain is confined to that region and there may be a localized point of tenderness in the midline overlying the joint. The symptoms which are characteristic of sacro-iliac involvement are usually absent. However, none of the signs is positively diagnostic. All of the signs are rarely present in a single case.

The roentgenogram is by no means conclusive, as there are many cases in which pathological change is present, though the roentgenographic manifestations are negative, and also there are instances of positive findings which may have no definite bearing on the existing symptoms, for instance, there may be a definite destruction or proliferation in one sacro-iliac articulation, but with all symptoms confined to the lumbosacral region. However, in a large percentage, differentiation may be made by the routine physical and roentgenographic examination. The lumbosacral region is quite analogous to the upper abdomen and bears the same relation to orthopedic surgery that the upper abdomen does to general surgery—it is a region of doubt.

An analysis of 63 cases which have been operated upon will be of material value at this time. The distribution of the local pathology in the cases is as follows:

	Cases
Infection	5
Trauma	11
Congenital anomalies	3
Benign tumors	1
Tuberculosis	13
	63

Tuberculosis is, of course, also an infection, but as the status of this disease is such a different problem, a separate discussion and classification is made for better comprehension. Of the 13 tuberculous patients, 11 were adults, 5 males and 6 females; 2 were children. The ages ranged from 10 to 45 years.

In those in whom the etiology was other than tuberculosis, 35 were males and 15 females, ages varying from 17 to 53 years. In this group infection was by far the most frequent cause, being present in 35 of the 50 non-tuberculous cases. Four cases of infectious origin gave a definite history of trauma, while in 11 of infectious origin the relation of trauma to the cause was doubtful and indefinite. In the 35 remaining cases there was not a scintilla of evidence of injury. In one with atrophic and destructive changes, there was a spondylolisthesis, without a history of injury.

Trauma may, of course, be an instigating factor whenever there is a defect in the skeleton from any cause, but should only be considered as a primary factor when there is a definite relationship between the trauma and the onset of symptoms. There were 11 cases in this series in which we believe that trauma was undoubtedly the sole

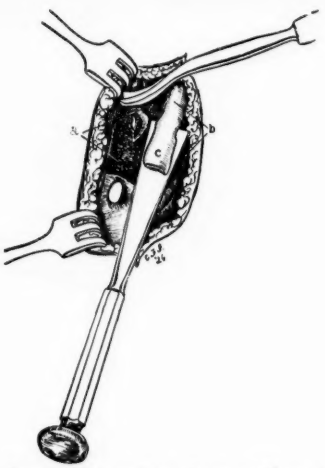


Fig. 2. Removal of a portion of crest of ilium; A, sacrum; B, ilium; C, fragment from crest of ilium.

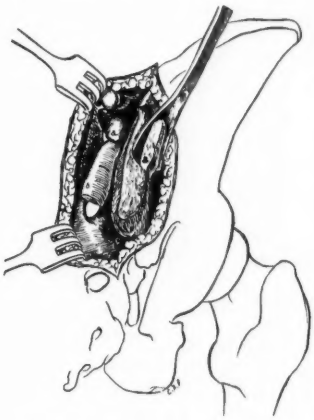


Fig. 3. Placing of multiple chips into denuded gutter formed by posterior surface of sacrum and inner surface of dorsum of ilium; A, small bone particles; B, large bone fragment.

cause. In 5, gross fractures could be demonstrated by the roentgenogram, and in 2 spondylolisthesis. In 4 instances no pathology was apparent, but as the injury and subsequent symptoms were so severe and persistent, the diagnosis of low-grade traumatic arthritis was warranted. Even in those with definite traumatic lesions the possibility of associated infections from a distant foci must always be considered, especially in those past 35 years of age. Sacro-iliac dislocation or separation, though frequently diagnosed erroneously, is of rare occurrence, and can be caused only by such violent injuries as being caught between two box cars, but even then the ilium is more frequently fractured parallel with the articulation. This error has often been due to the roentgenogram having been taken at such an angle that one joint has been apparently wider than its fellow on the opposite side.

Congenital anomalies, as enlarged transverse processes, spina bifida occulta, sagittal articular facets, and numerical variation can be considered only as a potential weakness and when present can not be accepted unequivocally until other possible agents have been excluded. But such gross defects as wedging, hemi-vertebræ with gross distortions and displacements, as occurred in the 3 cases reported, can be regarded as only a definite cause.

Static defects are usually associated with faulty posture and can be considered as a predisposing factor only. There is always associated generalized muscular and ligamentous weakness which is manifested by flat feet, lax joints, enteroptosis, etc. In no instance in our cases was this condition considered the sole cause, though it is well recognized that lumbosacral pain may be caused by faulty posture, especially increased lordosis. In this type of individuals, operative methods are rarely advisable, and we believe that treatment should be mainly general with an effort to correct body mechanism.

The object of all operative procedures in affections of the lumbosacral or sacro-iliac regions is to fix or splint, by an internal osseous bridge, the affected area, which may be one, two, or all three articulations. These procedures in the spine are well known and were devised by Albee and Hibbs, of New York, for the treatment of tuberculosis of the spine. Each have evolved a procedure and have proved conclusively that osseous fusion may be accomplished thereby. These measures have been modified in the lumbosacral region and several methods originated for the purpose of fusing the sacro-iliac joint, but only that of the author, reported in SURGERY, GYNECOLOGY AND OBSTETRICS, in August, 1927,[1] with such modifications as have been since employed, will be described in detail. The procedure of the author for fusion of the sacro-iliac joint has the advantage of being entirely extra-articular and of avoiding the danger of lighting up a latent infection, which is a most serious complication; especially is this true in tuberculosis of this articulation. The technique of the procedure in the sacro-iliac joint will be first considered and is as follows:

An incision is made along the outer lip of the crest of the ilium from the posterior one-third or

[1] Vol. xlv, 218.

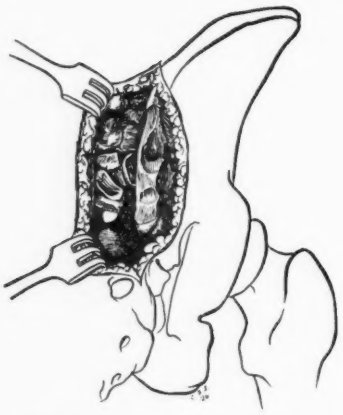


Fig. 4. Multiple grafts completely filling the denuded gutter.

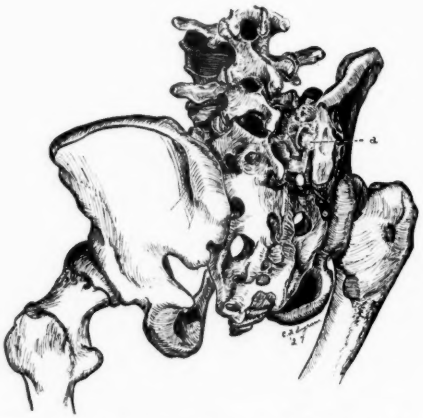


Fig. 5. Fusion between sacrum and ilium posterior to sacro-iliac joint.

one-half of the posterior inferior spinous process. This is carried down to the bone, where the periosteum is incised and elevated for a considerable distance, and the posterior portion of the dorsum of the ilium is exposed. The crest of the ilium is dissected free to raw bone and the adjacent fibrous tissue removed from the posterior surface of the sacrum beneath the region of the erector spinæ, or sacrospinal muscle. A portion of the crest is removed and placed in a towel. The inner surface of the overhanging portion of the crest of the ilium and adjacent posterior surface of the sacrum is denuded, thus forming a raw gutter made parallel with the sacro-iliac joint, formed by the posterior surface of the sacrum and the inner surface of the ilium posterior to the sacro-iliac joint. Into this space is placed the graft from the crest. Multiple grafts or "shavings" are next secured from the dorsum of the ilium and placed into the gutter until the space is well filled, when the wound is closed in layers. When desirous of also fusing the lumbosacral articulation, the anterior aspect of the transverse process of the fifth lumbar vertebra may be isolated and also denuded, after which the osseous graft from the crest of the ilium is placed into the gutter, already described, but extended upward to approximate the denuded surface of the transverse process of the fifth lumbar vertebra. In those cases in which it is necessary to fuse all three articulations, the same procedure may be carried out upon both sides, thus fusing both sacro-iliac joints and the fifth lumbar vertebra to the sacrum. This extension to include the fifth lumbar vertebra has only been recently applied in a small number of cases, but with distinct success. However, enough time has not elapsed to determine whether a sufficient area of the spine may be fused in this manner to relieve symptoms. After completion of the operation, the patient is placed on a Bradford frame for a period of 6 weeks, when a low-back brace with sacro-iliac belt is applied.

In those in whom fusion of the lumbosacral spine is required, in addition to fusion of the sacro-iliac joint, we have also employed a curved or convex graft from the crest of the ilium, which we have transplanted into the spinous process of the lumbosacral region after the manner of Albee.

The lumbosacral region alone has also been fused by the Albee graft where the spinous processes are in the same plane, but unfortunately there is considerable lordosis in many patients. Therefore, it is often necessary to break down the spinous processes, denude the laminæ, and then transplant an osteoperiosteal graft from the tibia which conforms accurately to the lumbosacral region, and which is a combination of the principles evolved by Albee and Hibbs.

Of the 63 patients, there were 47 in whom operative measures were applied for fusion of lumbosacral articulations; 34 of these were fusion of the lumbosacral articulation alone, and 13 were fusions of the lumbosacral articulation combined with fusion of one or both sacro-iliac joints. In 2 patients the sacro-iliac articulations were fused; in 16 cases the sacro-iliac joints alone were fused; and in 13 cases fusion of both lumbosacral and sacro-iliac joints was performed. In 16 cases of fusion of the lumbosacral joint, the Albee method was employed; in 3 cases of fusion of the sacro-iliac joints the procedure described by Smith-Petersen was

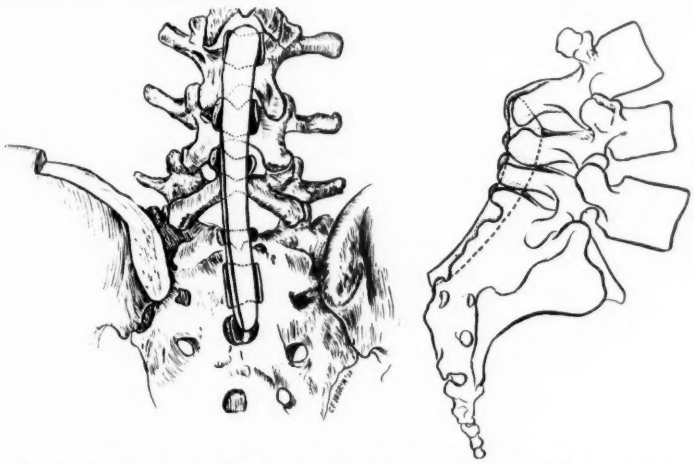


Fig. 6. Fusion of lower lumbar vertebræ and sacrum, by means of a curved graft from crest of ilium.

used. In the remaining cases the methods devised and employed by the author, as described, were used. The results of the Albee operation, as demonstrated by the roentgenogram, were excellent, but estimation as to the clinical result can not be given, as the procedure was so often combined with an operation for fusion of the sacro-iliac joint. However, there was every clinical evidence that this was an excellent method by which the spine could be fused. The number in which the Smith-Petersen operation was used is too small to consider. The results of the operative treatment in the 63 cases may be estimated in the accompanying tables:

By excellent is meant complete relief. In those classed as good, symptoms persisted to some extent, but there was permanent and lasting improvement. There were two deaths in attempted fusion of the lumbosacral and sacro-iliac joint at one operation. In both, the crests of the ilia were transplanted into spinous processes, as described. Since these fatalities we do not employ this method, except in very robust individuals. There was no mortality in those in which fusion of the lumbosacral and sacro-iliac or bilateral fusion of sacro-iliac and lumbosacral by the other methods described.

In the tuberculous cases there were no operative deaths. The deaths reported were the result of complications occurring some time after operation. In the death following attempted fusion of the sacro-iliac joint the procedure was intra-articular, and death was due to tuberculous meningitis.

The roentgenogram demonstrated definite abnormality of the articulation in 54 cases. In 9, no abnormality could be demonstrated which very clearly illustrates the value of the X-ray as an aid to diagnosis.

Operations have been devised for fusion of all three articulations, as there is some difficulty in determining the exact location of the pathological process, and, also it has been suggested that, when one or two joints are arthrodesed, symptoms are induced in the remaining joint by undue stress, strain, or shearing action. In the series reported, we have fused only those joints in which there was clinical evidence of disease, and in only two instances have symptoms occurred in adjacent joints after fusion has been accomplished. Therefore, unless a higher percentage of successful results can be demonstrated by routinely fusing all three articulations, more extensive surgery is not at present indicated. Of course, when there is apparent pathology in all three articulations, fusion of all is advisable, but whether this can be efficiently accomplished at one operation with safety to the patient remains to be demonstrated.

In conclusion, I desire to emphasize that—

1. Conservative measures, when possible, should be employed before fusion operations are considered.

2. In all cases with tuberculous involvement, fusion operations are indicated as early as possible.

3. In those cases with persistent symptoms and definite abnormalities demonstrated by the roentgenograms, fusion operations are advisable.

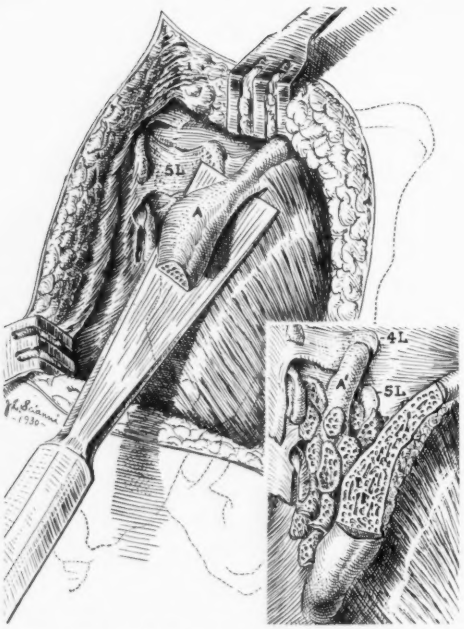


Fig. 7. Removal of posterior portion of the crest of the ilium. Insert shows removed portion of ilium, A, lying on denuded surfaces of sacrum and transverse processes of fourth and fifth lumbar vertebræ. Multiple chips are placed about the portion of the ilium and into the denuded gutter.

4. In those cases in which the symptoms persist, even though the roentgenogram will demonstrate no pathology, fusion is indicated, but only after all extraneous causes have been carefully excluded.

5. Fusion operations are often indicated much earlier in wage earners, especially in those who do not depend upon compensation and can not give sufficient time for conservative treatment.

6. Fusion of the lumbosacral articulation causes no practical disability. Flexion of the spine may be slightly limited. Fusion of the sacro-iliac causes no disability.

7. These procedures should be carried out with precision. If unduly prolonged, shock with an increase in the percentage of fatalities is to be expected. Not over one hour should ever be consumed for operation, and in most instances, much less.

8. The operative mortality from fusion of any one articulation is practically nil, and, with sufficient care, should be exceedingly low in all procedures in this region.

9. The percentage of successful results here reported very clearly proves the value of these operative measures and that chances of permanent cure are excellent in a type of case in which permanent disability often persisted.

TABLE I.—NON-TUBERCULOUS

	Excellent	Good	Poor	Died	Unknown	Total
Sacro-iliac (alone).....	7	0	2	0	2	11
Lumbosacral and sacro-iliac....	6	1	3	2	1	13
Lumbosacral (alone).....	14	4	2	0	6	26
	27	5	7	2	9	50

TABLE II.—TUBERCULOUS

	Excellent	Good	Poor	Died	Unknown	Total
Sacro-iliac.....	2	0	2	1	0	5
Lumbosacral....	6	0	0	2	0	8
	8	0	2	3	0	13

FRACTURES OF THE ACETABULUM[1]

WILLIAM R. CUBBINS, B.S., M.D., F.A.C.S., ARTHUR H. CONLEY, S.B., M.D., AND JAMES J. CALLAHAN, M.D., CHICAGO

DUE to the peculiar strains and severe injuries incident to automobile and aeroplane accidents, fractures in and around the acetabulum are becoming far more common. Such fractures are difficult to diagnose when considered from a clinical standpoint and only too frequently it happens that a single X-ray film fails to show the essential pathology present. For this reason stereoscopic and oblique plates should be made. In our service we have had several cases of fracture of the acetabulum, and the more we have considered them the more we are interested in the classification, the treatment, and the prognosis. We have not been entirely satisfied with the classification as presented in the various texts and articles.

As in almost every type of fracture of the acetabulum there is the possibility of serious disturbance in the function of the hip joint, more care should be used in diagnosing these cases so that treatment can be started at an early period. In our series the four serious failures are due to delay and mistreatment. In Case 2 (Pardoni) and Case 3 (Cashion) treatment consisted in extension on a Hawley table and the application of casts. In the third case, Case 6 (Cheluk) no treatment was given for 2 weeks. In this case we feel reasonably sure that had we been able to institute early treatment an excellent result could have been obtained. In the fourth case, the patient, Magdrerz, was seen at the end of the ninth week and nothing could be done with manipulations and open operation was refused.

Some fractures, particularly those of the rim, should be operated upon at once or at least before the small fragments have been crushed, absorbed, or so misshapen by new growth that they cannot be replaced correctly. We do not consider that the method described in this paper, of using a screw in the trochanter for traction should be called radical treatment. We have found that it is very simple and we feel that it is conservative. However we are sure that many injuries occurring in this area will be treated with radical open operation and accurate replacement of the fragments when the condition is better understood. In order to stimulate systematic thinking in relation to fractures of the acetabulum, we are submitting the following classification, which no doubt, will require many corrections and frequent rearrangements. However we trust that it will be an aid to others in clearing up the conception of the etiology and morbid anatomy of such fractures.

CLASSIFICATION OF FRACTURES OF THE ACETABULUM

A. *Fractures of the rim.*
   1. An oblong fragment on the posterior lip of the acetabulum, essentially that portion contributed by the ischium in its development.
   2. An oblong fragment, essentially that portion contributed by the ilium.
   3. An oblong fragment, essentially that portion contributed by the pubic bone.

B. *Fractures of the acetabulum involving one or two of the three bones of which it is formed.*
   1. Fracture with displacement inward and backward of the ischial segment and ramus.
   2. Fracture with displacement inward of the pubic segment and ramus.
   3. Fracture displacing both the pubic and ischial segments with rami.
   4. Fracture with displacement inward and backward of the ilial segment.

C. *Perforating fractures.*
   In this type the head is forced through the bottom of the acetabulum with a very small amount of the surrounding bone.

D. *A Fracture so extensive that all of the bones are involved and fragmented.*

ETIOLOGY

In dealing with the etiology of these fractures it is obviously necessary to deal with those of the rim separately from those involving the deeper portions of the cup. We have one history of an individual being knocked off a wagon and landing heavily on the left foot, thus causing a fracture of the upper and posterior portion of the rim of the left acetabulum. We have one case of a man 65 years of age, who, while sitting in the right hand seat of an automobile in a head-on collision, suffered a fracture of the ilial segment of the acetabular rim. This is shown in Figure 1 (Stark). This man was unconscious, sitting upright in the seat. Obviously his right knee had been jammed against the dash and the aftercoming pelvis had caused fracture of the acetabular rim.

The fracture of the acetabulum which is characterized by a perforation or by an involvement of one of the three divisions, or by all of the divisions, can be produced only by applying a heavy force to the trochanter major, such as occurs when

[1]Read before the Southern Surgical Association, Atlanta, Georgia, December, 1929.

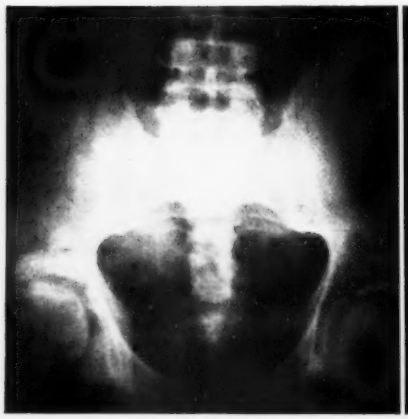


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1. Starck. Fracture of the ilial segment of the acetabular rim. No treatment was given except rest in bed for 8 weeks. Result poor. Marked arthritis and severe crippling.

Fig. 2. Pardoni. Fracture through the ischial segment with dislocation inward and backward of the segment and the ischial ramus. Treated with traction on a Hawley table and a cast. No improvement.

Fig. 3. Cashion. Fracture of the ischial segment with dislocation inward and backward of the segment and the ischial ramus. Treated with traction on a Hawley table and a cast. No improvement.

one falls and lands heavily on his side. Numerous cases of this type are in the literature and, in fact, a fall is the causative factor in the great majority of the cases in the old literature. At this time the automobile, the steam or electric cars, and the aeroplane are essential factors in adding to the frequency of the lesion.

Surgeons became interested in the mechanics of the production of acetabular fractures 30 years ago. A series of experiments were made by Vireveaux, of Lyons, France, in 1898, and he published a report as a thesis in 1899. In this work Vireveaux used a very heavy metal hammer to produce the force. The leg was extended and slightly abducted when the trochanter was struck with the hammer. Four acetabular fractures were thus produced, one of which was of a perforating type. The neck of the femur was broken many times. In two experiments on one cadaver the knee was struck with the sledge and the result was described as negative.

The next experimental work was done in the anatomical laboratory of Northwestern University Medical School by Charles M. Fox, working with and under the direction of Dr. William E. Schroeder. A description of this work was published in the *Quarterly bulletin of Northwestern University Medical School* in April of 1909. In the same issue Schroeder reported two new cases with a résumé of each of the 46 cases that had been reported previously in the literature. These papers are classics and should be read by everyone interested in these fractures. The following is taken from Fox's article:

> We took fourteen cadavers and used only a five-pound hammer, striking the trochanter with the leg extended and slightly adducted. Of the femurs so treated, four promptly fractured the acetabulum in various directions. A fragment of the ilium, one from the ischium, and one from the pubis constitute the so-called inverted Y shaped fracture and allowed the head of the femur to protrude. The other results were not so typical, the lines of fracture running into the obturator foramen, into the ischiatic notch, and through the rami. Of the remaining six experiments there was one impacted fracture of the neck of the femur and two fractured trochanters and three fractured necks. In four cadavers the blow was applied to the knee resulting in four fractures of the neck of the femur; it seems to me the greatest importance is to be attached to the position of the head and neck of the femur and the blow. If the force is suddenly applied the elasticity of the pelvis will be of little or no consequence and the head will be forced through the acetabulum. Whereas a slow force will be associated with vertical, ring, and other fractures of the pelvis.

From this description it is apparent that these investigators were seeking the perfect Y shaped or perforating fracture and that the other types of fractures did not interest them sufficiently at this time to observe the other variations carefully or to seek the reason for them. What actually happened undoubtedly was that the adducted limb was indifferently rotated, either medially or laterally so that the slight deviation of the line of force caused the unexpected and unsought results. The

Fig. 4.

Fig. 4A.

Fig. 4B.

Fig. 4. Alar. Fracture through the ischial segment with dislocation inward and backward of the segment and ramus.

Fig. 4A. Alar. Under traction, longitudinal, with Buck's, and lateral, with screw and wire attached.

Fig. 4B. Alar. End-result; joint cavity clear cut and distinct, but a portion of the ramus and segment is still out of place. Function, 80 per cent.

statement that the other results were not so typical, the lines of fracture running into the obturator foramen, ischiatic notch or through the rami, bears us out in this assumption.

From the cases we have studied we believe that the fractures of the various parts of the acetabulum are the result of deviations in the position of the trochanter major.

In Figures 2 (Padoni), 3 (Cashion), and 4 (Alar), we have illustrations of the first division of the classification. In these there is a dislocation inward and backward of the ischial segment of the acetabulum, this segment carrying the ramus of the ischium with it and causing a fracture at the junction of the ascending ramus of the ischium with the descending ramus of the pubis.

Figure 5 (Magdrerz) shows a fracture of the pubic segment of the acetabulum with a dislocation inward and downward of pubic ramus, which is No. 2 of division B of our classification.

The third division of B is shown in Figures 6 (Cheluk) and 7 (Corona) in which we see a fracture that included both ischial and pubic segments with dislocation inward of the rami.

As yet we have not encountered a fracture involving the ilial segment alone. We have no case to illustrate the true perforating type. However, in Figure 8 (Driscol), we see a fragmentation involving all of the bones entering into the formation of the acetabulum.

In making deductions as to the mechanics involved in the production of these fractures, it seems to us that the ischial fracture dislocations as shown in Figures 2, 3, and 4, are caused by the force striking the trochanter with the thigh adducted, flexed, and rotated inward.

In Figure 5, the force must have been applied to the trochanter with the thigh flexed, adducted, and rotated outward. As yet we are not clear as to the position of the thigh and direction of the force necessary to produce the condition shown in illustration Figures 6 and 7 where the entire lower half of the acetabulum and both pubic and ischial rami are fractured and dislocated. This might be from the force striking the trochanter with the thigh either straight or slightly abducted. There are no reports indicating that this type of fracture has been produced by experimental work. It is our opinion that many of the more extensive fractures of the acetabulum never reach the surgical ward because death occurs rapidly from rupture of the iliac arteries and veins thus producing extensive hæmorrhage.

PATHOLOGY

With the exception of the fractures of the acetabular rim, the trauma to adjacent structures is a

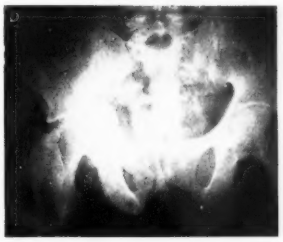


Fig. 5. Fracture of the pubic segment with dislocation inward and downward of the segment and pubic ramus. Seen in ninth week. Position could not be changed. Thirty per cent flexion possible. No adduction or abduction.

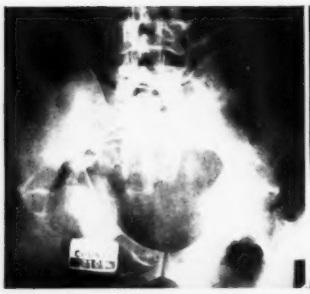


Fig. 6.

Fig. 6. Cheluk. Fracture of the ischial and pubic segments with dislocation inward of the segments and rami. The roentgenogram was taken at the end of the second week.

Fig. 6A.

Fig. 6A. Cheluk. Result of longitudinal and lateral traction. Function good—about 75 per cent.

Fig. 6B.

Fig. 6B. Cheluk. End-result fair, probably caused by delay in beginning treatment.

very important factor in these injuries. In the cases collected by Schroeder and Fox, which date from the first report of Sir Astley Cooper, in 1821 up to 1909, most of the material is derived from postmortem examinations; and it is from these cases and Schroeder's operative case that we get the best idea of the extensive injury that is inflicted upon the viscera of the pelvis by fractures of the acetabulum. The iliac veins and the iliac arteries are commonly injured so that there are extensive hæmorrhages that are frequently fatal. These hæmorrhages in some instances extend up to and surround the kidney, and they may also extend into the anterior wall of the abdomen beyond the midline, properitoneally. Blood is always found down and around the rectum and in the perineum and scrotum. Consequently, when a patient with a peculiar abdominal lesion is observed following severe trauma, the pelvis must be very carefully examined.

The obturator, femoral, and sciatic nerves are not uncommonly involved, both by lacerations and by pressure. The rectum and small bowels were perforated in different cases. The bladder was frequently injured by spicules which transfixed it; and great extravasations of urine were common.

If these individuals recover from their injury without a reduction of the dislocations, the head becomes firmly walled in with a mass of bone that will block out about one-third of the pelvic area. In one case of this type the patient bore a child following the accident and the parietal bone of the child was grooved as the head passed the obstructing femoral head. Sometimes, when the head protrudes into this cavity, the attempts at reduction are blocked by the locking of the fragments around the head in such a manner that only open operation will free the fragments and allow the head to be pushed back into a normal position. Once in position the head must be held by traction, both lateral and longitudinal, during the wound closure and traction must be continued for 6 weeks.

SYMPTOMS

The symptoms of fractures of the rim and the more extensive fractures of the acetabulum must be taken up separately.

In rim fractures, pain on motion and loss of function are always present. Tenderness around the outer surface of the joint can be elicited in thin or moderately large individuals; and we believe that as a rule the tenderness will be over the fractured segment of the rim. A subluxation will be present in a certain number of rim fractures; and, conversely, a segment of the rim can be torn off with a luxation.

If the ischial portion of the rim is fractured and the patient is in a recumbent position, the limbs will be of the same length. Flexion of the limb and medial rotation of the femur will give a peculiar click and jump. The femur then tends to remain flexed and adducted, but can be easily restored to the original position. If this condition goes undiagnosed and untreated, serious disability will result, due to repeated subluxations which are painful. Later a chronic, traumatic arthritis will develop with more or less destruction of the joint tissues.

If the ilial segment of the rim is fractured, a slight adduction is sometimes necessary to make it click. If the pubic segment is injured it can be put into a position of subluxation for diagnosis only by extension and outward rotation.

In fractures of the acetabulum which are perforating or fragmented, three very different groups

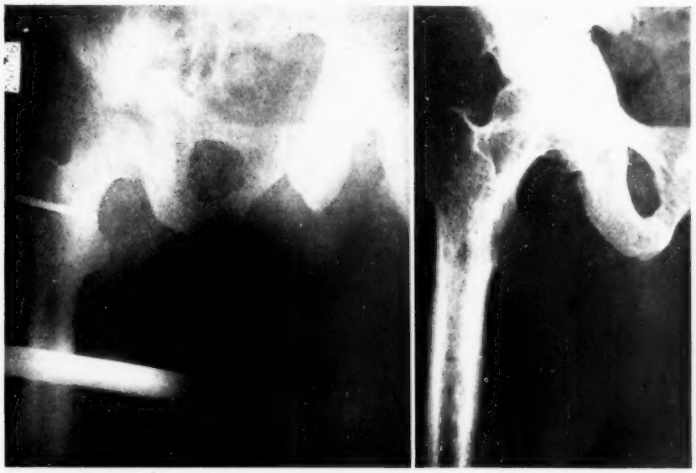


Fig. 7, left. Corona. Fracture of the ischial and pubic segments with dislocation inward of segments and rami. We do not believe the direction of this screw is to be as satisfactory as that shown in Figures 4A and 8A.

Fig. 7A. Corona. Result of longitudinal and lateral traction. Excellent function in the hip joint.

of symptoms are present: (1) those in relation to the limb and its function, (2) those in relation to the abdomen, and (3) those in relation to the genito-urinary tract and rectum.

The length of the limb varies; sometimes it shows a marked shortening; at other times it is of the same length and in 3 of our cases it was from ½ to 1 inch longer. The trochanter is less prominent and is sometimes below Nélaton's line. The limb may be straight on the table with the foot up; there may be a little inversion if the femoral head has passed back through the ischial portion; or there may be eversion of the leg and foot if the femoral head has been driven forward through the pubic segment. Any motion, active or passive, is painful, but flexion is usually possible. Abduction is seldom possible. Adduction is possible but limited. Rotation varies with the extent of the fragmentation and the amount of displacement, but it is usually absent. Tenderness around the outer posterior surface of the joint is always present, due to the fact that pressure must necessarily be made upon the head of the trochanter in order to force the head through the pelvis. Extensive bruises over the trochanter major are common.

Marked tenderness over the lower abdomen is nearly always present and particularly severe on the side of the injury. Rigidity is common. Nausea and vomiting are not uncommon, without injury to the viscera, and are due to the mass of blood and fragments irritating the parietal peritoneum. Fatal intra-abdominal hæmorrhages from the iliac vessels have been noted many times in the literature.

Blood in the urine, due to ureteral, bladder, and urethral injuries, is common, although one must not forget the possibility that the kidney has been ruptured by the injury which caused the acetabular fracture. Tenderness over some portion of the pubic and ischial rami is always present. By rectal or vaginal palpation marked tenderness can be elicited and, commonly, a mass will be found where the fracture is located, whether there has been a dislocation inward of the fragments or only a hæmorrhage from the fractured bone.

PROGNOSIS

Prognosis varies with the extent of the injuries to the large blood vessels and the hollow viscera. Many die after a few hours from shock and loss of blood and quite a few from undiagnosed injuries of the intestines. In our opinion, in order to locate an uncontrolled hæmorrhage or a perforated viscus, exploratory operation is indicated, if there is any doubt as to the diagnosis. If coroners' physicians would make postmortem examinations upon all of the so-called deaths from internal injuries, they would quickly demonstrate that this injury is a very common cause of death.

Fig. 8.

Fig. 8. Driscol. The roentgenogram shows fragmentation of the three bones forming the acetabulum with inward displacement.

Fig. 8A.

Fig. 8A. Driscol. Longitudinal extension with Buc's and lateral with screw in the trochanter.

Fig. 8B.

Fig. 8B. Driscol. Function of hip joint perfect.

Owing to this lack of postmortem control however, the mortality has been very low. We have not encountered any of these cases in operating for acute abdominal conditions the result of trauma; and the 7 cases that have reached the fracture ward have recovered. In none of these has there been lesions of the vessels that caused any disturbance of the peripheral circulation. The viscera and genito-urinary organs have not been involved in a single case. There has been one case with pressure upon the obturator nerve, but, in spite of this brief record, we are certain that we will soon encounter a group of these cases with serious complications, such as traumatic aneurism, thrombosed veins, lacerated nerves, and perforated bowels.

TREATMENT

Treatment obviously must first meet the emergencies, as they are presented, from repairing blood vessels and perforated viscera to any of the simpler lesions.

The rim fractures should, in our opinion, be operated upon early. The fragment should be restored to as near normal position as possible and should be held in place by suitable means. If such fractures are seen late, some plastic measures should be taken to restore the acetabulum, although some surgeons advise ankylosing the hip for this condition.

In the group characterized by perforation or fragmentation, the attempts at reduction should be made as soon as possible after injury. An anæsthetic that will give complete relaxation should be used. Whether it will be necessary to use spinal anæsthesia because of the presence of fractured ribs and pulmonary injuries, which are commonly associated with these fractures, is a question to be determined by the surgeon. A central dislocation of the femoral head is always held in central dislocation by the tone of the great thigh and buttock muscles. In order to relieve this, we have found that flexing the thigh on the abdomen, adducting gently across the abdomen, rotating the femur inward, and exerting traction with a somewhat lateral outthrust of the femur will reduce the dislocation. The limb is then straightened gently upon the table. In some cases the head immediately slips back into the dislocated position, but in others it will remain in a relatively normal position. The head will remain in relatively normal position in cases in which the large upper surface of the acetabular cup remains but it will not remain in the reduced position if only a thin rim of the upper edge of the acetabulum is present, as shown in Figure 6 (Cheluk).

There is little difference in the motions used to reduce these so-called central dislocations but one must be very sure of the morbid anatomy present before undertaking any strenuous movements for fear of doing more harm.

In a true perforation, the head is sometimes locked. In such cases an incision parallel with

and above Poupart's ligament should be made, the tissues pushed away, and the restraining fragments unlocked from the neck and head. The head can then be forced out and held out by traction while the fragments are replaced and the wound closed (see article by Schroeder).

We believe that all of these cases need both longitudinal and lateral traction. Longitudinal traction is obtained with Buck's extension and a Thomas splint for support of the limb. Lateral traction is obtained by means of an incision made just below the trochanter major parallel with the long axis of the limb, a hole being drilled through the upper end of the firm cortex, through which a 4 inch wood screw is placed, preferably in the direction of the neck. The head of this screw protrudes through the wound and copper wire is wrapped firmly around the protruding head. (Figures 4A and 8A.) To the wire is attached a 15 pound weight which extends laterally over a horse or arm extending from the bed. Twenty pounds of weight are used at first for the longitudinal pull, the weight is later reduced to 10 pounds.

Another method of exerting lateral pull on the femoral head is by means of weights attached to a Steinmann pain which is inserted through the trochanter from before backward. This procedure naturally results in severe trauma to the tissues, and we believe that like traction with a Steinmann nail or a tongs it will be a frequent cause of pain and discomfort. For heavy lateral traction for a short interval during reduction, Cotton's method of using a strap around the inner side of the thigh is a very excellent one, but it cannot possibly exert a pull in the desired line as accurately as will a screw which is placed in the trochanter major and which extends up through the neck; furthermore if the strap is held in place for a long time it will interfere with the circulation of the limb.

The weights may be lessened after a few days, but a good substantial pull should be maintained for at least 6 weeks and no weight should be borne on the limb for 4 to 6 months. We do not believe that a walking caliper is indicated because the walking caliper will press upon the ischium and serve only to dislocate the ischium upward; as a matter of fact, it would defeat our efforts. The patient should be made to use crutches with a minimum of weight upon the extremity for 4 months and then gradually increase the weight carrying as the limb becomes stronger.

The end-results of this longitudinal extension with the adhesive plaster after the method of Buck and the screw in the trochanter are shown in illustration Figure 4B (Alar), Figure 6A (Cheluk), Figure 7A (Corona), and Figure 8B (Driscol). Corona and Driscol have nearly perfect hip joints. Alar and Cheluk could be classed as about 50 per cent satisfactory. In Figure 4B, in spite of traction there is a portion of the ramus of the ischium still in a position of displacement. We are not able to account for the clear-cut, apparently perfect acetabulum, and this displaced fragment. We are not sure as to just what factors are the most effective in drawing these fragments back into place, but in all probability it depends entirely upon the capsule of the hip joint remaining in contact with the fragments.

In conclusion, we wish to emphasize that we believe that by a careful analysis of each case and the necessary slight change in the direction of the skeletal traction these fairly good results may be very much improved. We have used the ordinary screw wrapped with wire around the head, but Dr. Edwin W. Ryerson has suggested that we use a screw with a hook or ring at the end. With a ringed screw it would not be necessary to use a screw-driver to insert it and there would be less danger of the attached weight slipping off.

ELIMINATION OF PAIN IN OBLITERATIVE VASCULAR DISEASE OF THE LOWER EXTREMITY

A Technique for Alcohol Injection of the Sensory Nerves of the Lower Leg

R. H. SMITHWICK, M.D., and J. C. WHITE, M.D., Boston
The Peripheral Circulatory Clinic, Massachusetts General Hospital

DURING the past few years, there has been a general trend toward conservatism in the treatment of obliterative vascular lesions of the extremities. It has been the usual experience of those most familiar with this group of cases, that major amputations are frequently necessary on account of uncontrollable pain. Pain may be temporarily relieved by numerous procedures, designed and advocated to stimulate the peripheral circulation such as: ligation of peripheral arteries (9) and veins (11, 12), periarterial sympathectomy (2, 8), periarterial injection of alcohol (7, 10), dorsal and lumbar sympathetic ganglionectomy (1, 5), and the use of foreign protein (3 and 5). In spite of these aids, it has often been necessary to amputate the painful leg to preserve the patient's morale and to prevent him from becoming a morphine addict.

It is our intention to show that it is rarely necessary to amputate an extremity because of pain, and furthermore that extremities which hitherto have been undoubtedly doomed to amputation because of indolent, sensitive, painful ulcerations, can often be saved if the pain factor is eliminated for a sufficient length of time to give conservative procedures a chance to take effect. It should never be necessary to amputate an extremity unless it is hopelessly gangrenous or unless intervening sepsis threatens the life of the patient.

Attempts have been made in the past to block the sensory nerves to the foot. Quenu cut the digital nerves by making small lateral incisions at the base of the toes. Corlette (6) recommended cutting the terminal sensory nerves by a transverse subcutaneous incision just above the painful ulcer. Silbert (13) reported 4 cases of blocking the posterior tibial nerve with alcohol at the internal malleolus (in one the foot became gangrenous, in another the wound healed slowly, but pain in the toes was relieved in all). However, any operative procedure below the ankle is in the zone of impoverished circulation. Therefore, the incision is liable to heal poorly and injection of alcohol into the tissues is quite likely to cause extensive sloughs.

As far as we know no one has tried to work out a systematic method of blocking all the sensory nerves to the lower leg and foot and of exposing them high enough in the calf to give a good chance of primary union to the wound edges.

The anatomical arrangement of the nerves in the leg is very favorable for sensory block, whereas in the arm, the important nerves lie close together and give off important motor branches throughout their entire length. In the leg the trunks are widely separated, many are purely sensory, and the mixed nerves give off no important muscular branches in the inferior two-thirds of the lower leg. If desired, a complete anæsthesia of the lower half of the leg and foot can be produced with no loss of motor function except in the small intrinsic muscles of the foot. These are relatively so unimportant that in 5 cases in which they have been temporarily sacrificed, the patient has subsequently walked without a detectable limp.

Types of Cases Suitable for Nerve Blocking

To date we have operated upon 11 patients. Table I shows the types of cases treated, the nerves injected, and the end-results. With rare exceptions, the operative incisions healed by first intention. These cases showed no important muscular paralyses. All were relieved of their pain, although in Cases 4 and 8, there was an extension of the gangrene into an unblocked painful area. After the sensory nerves were blocked, no further morphine or other drugs was necessary for the relief of pain and the patients were able to sleep soundly without sedatives. Furthermore, thorough Dakinization of the previously hypersensitive ulcerated areas could be carried out, and it was possible to cut away infected toe nails and bits of necrotic fascia and tendon without any discomfort to the patient.

Surgical Anatomy of Sensory Nerves in the Leg

We have found that even in cases of definite gangrene of the toes, small operative incisions made under local anæsthesia heal well as low as the junction of the middle and lower thirds of the leg. In the presence of ulceration as high as the mid-calf, it is still possible to desensitize the entire area without producing important muscular

TABLE I.—TYPES OF CASES AND RESULTS

Case	Age	Disease	Local condition	Nerves blocked	Healing of operative incision	End-result
1	39	Thrombo-angiitis obliterans	Great toe amputated for gangrene. Sepsis and severe pain in stump	Posterior tibial	First intention	Slow but painless healing of disarticulated toe in 2 months.
2	36	Thrombo-angiitis obliterans	Ulceration of tip of great toe	Cutaneous branch peroneal, posterior tibial	First intention	Terminal phalanx and nail avulsed without pain. Toe painless but not healed at 1 month.
3	36	Thrombo-angiitis obliterans	Gangrenous 2nd and 3rd toes with infection of plantar fascia	Cutaneous branch of peroneal, anterior and posterior tibial	First intention	Amputation of gangrenous toes with drainage of plantar fascia healed in 2 months.
4	43	Monkeberg's sclerosis	Beginning gangrene of first three toes	Cutaneous branch of peroneal and posterior tibial	First intention	Gangrene and pain spread to anterior tibial nerve. Gritti-Stokes amputation.
5	70	Arteriosclerotic gangrene	Threatened gangrene foot with severe pain first three toes	Cutaneous branch of peroneal, anterior and posterior tibial	First intention	Painless gangrene of foot in 10 days. Gritti-Stokes amputation.
6	70	Arteriosclerotic gangrene	Non-healing ulcer lateral lower third of leg	Peroneal anastomotic and external saphenous branches of sural nerve	Delayed healing	Ulcer healed slowly and painlessly.
7	67	Arteriosclerotic gangrene	Ulcer 5th toe with septic joint	Posterior tibial and cutaneous peroneal	Slight sepsis	Relief of pain, stump toe healing slowly
8	70	Arteriosclerotic gangrene	Painful gangrene great toe	Posterior tibial nerve	First intention	Relief of pain, gangrene advanced slowly, forcing amputation.
9	62	Arteriosclerotic gangrene	Painful gangrene 5th toe	Posterior tibial and cutaneous peroneal		Rapid spread of gangrene, amputation
10	43	Thrombo-angiitis obliterans	Painful ulcer great toe	Posterior and anterior tibials, cutaneous peroneal	Slight sepsis	Complete relief of pain. Final amputation as ulcer did not heal.
11	37	Thrombo-angiitis obliterans	Painful ulcers dorsum of foot and great toe	Posterior tibial, cutaneous peroneal, sural	First intention small skin slough	Pain relieved. Ulcers grafted.

palsies. Of course it is of the utmost importance to use the most rigid aseptic technique to guard against trauma of the skin edges and deep tissues, and not to spill any alcohol in the surrounding structures. In performing the injections, we have freed up each nerve sufficiently to pass a gauze compress saturated in normal salt solution beneath it and have then injected enough 95 per cent alcohol through a fine needle to distend the sheath over a length of 2 to 3 centimeters (about 3 cubic centimeters of alcohol in the case of the posterior tibial, 1 to 2 cubic centimeters in the smaller nerves).[1] Then we have flooded the incision with normal salt solution, approximated the deep fascia with interrupted No. 0 chromic catgut sutures and the skin with fine silk.

Figures 1 and 2 show the sensory nerve supply of the leg. A study of these plates shows that a group of two or three nerves must usually be blocked to give an extensive anæsthesia, but in some cases two can be exposed through a single 2-inch incision. It is important to inject them high enough to include all collateral branches which may leave the main trunk higher up and come down independently into the painful zone. On the other hand, it is necessary to block the mixed nerves low enough to prevent paralysis of the important muscles in the calf.

The following procedures have been found to carry out these fundamental requisites:

1. *Posterior tibial nerve.* This nerve supplies sensation to the entire sole of the foot extending over onto dorsum of toes to include distal half of the nails (Fig. 9, B). Figure 3 shows the general relations of the nerve in the leg and its important muscular branches. It is to be noted that the last muscular filament, the inferior nerve to the flexor hallucis longus muscle, leaves the trunk at the junction of the lower and middle thirds of the leg, i.e., 6 inches above the ankle. It is best to inject the nerve just below this point, but even if this inferior branch were cut, the flexor muscle of the great toe would not be paralyzed as it is supplied with a large superior branch which comes off 5 inches higher up.

The incision is made 5 inches above the internal malleolus parallel to the posterior angle of the tibia (Fig. 9, B). When the deep fascia is cut

[1] During the period in which this article has been in press we have seen two small trophic ulcers develop from anæsthesia lasting over 6 months. In order to avoid this we are now injecting much smaller amounts of alcohol than those recommended above—not over 1½ cubic centimeters for the injection of the posterior tibial nerve and ¾ cubic centimeter for the anterior tibial. A simple crushing of the other smaller nerves by a hæmostat has given a satisfactory anæsthesia for 3 months. It is most desirable that regeneration should take place in from 3 to 6 months in order to avoid neurotrophic complications.

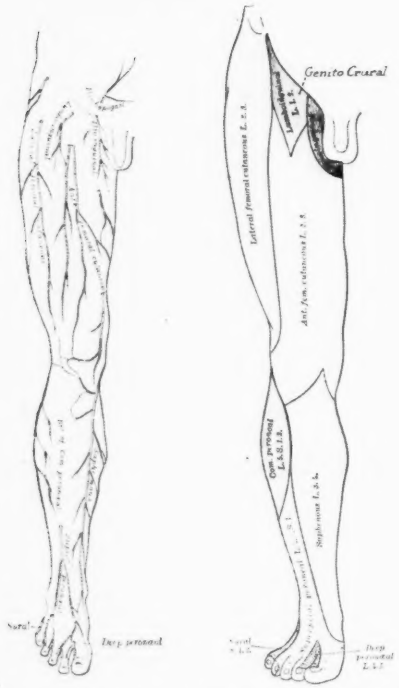


Fig. 1. Cutaneous nerves of the lower extremity. Front view. From Gray's *Anatomy*, Lea & Febiger, 1918.

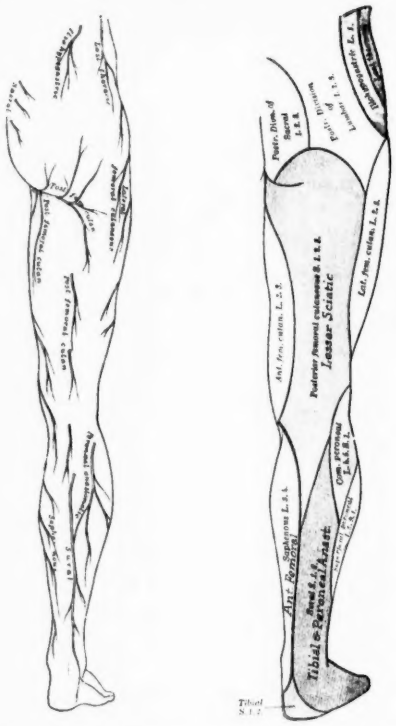


Fig. 2. Cutaneous nerves of the lower extremity. Posterior view. From Gray's *Anatomy*.

through, the cleavage plane between the flexor digitorum longus and soleus gastrocnemius muscles is entered (Fig. 4). With blunt dissection and adequate retraction, the neurovascular bundle is easily exposed (in a leg of average size it lies about 1½ inches beneath the skin). The nerve normally is the deepest of the three structures, but anatomical variations are frequent. In cases of Buerger's disease, the nerve may be fused to the artery and vein in a solid mass. Extremely gentle blunt dissection must then be employed to separate the structures in the mass, as the diseased vessels are friable and easily torn. An injury to the artery may easily turn the scale against a foot which is already balancing on the verge of extensive gangrene. Even if the artery appears to be completely thrombosed and pulseless, it can transmit a considerable volume of blood and must not be injured. When the nerve has been identified, it is freed up over the full length of the incision. It is then injected with 95 per cent alcohol by the method outlined above, and the incision is closed without drainage.

All of the small muscles of the sole of the foot are paralyzed for a period of 2 to 3 months, but if the patient wears some form of soft arch supporter, this temporary paralysis is almost unnoticeable.

2. *Deep peroneal nerve.* Block of this nerve produces anæsthesia limited to the contiguous sides of the great and second toe with a small area between the heads of the first two metatarsals (Fig. 5).

As in the case of the posterior tibial nerve, no important motor branches are given off in the lower third of the leg. Incision should be made 5 inches above the ankle and midway between the tibia and fibula. As shown in Figure 4, the neurovascular bundle is exposed by opening the cleavage plane between the anterior tibial and extensor digitorum longus muscles. The same precautions must be used in separating the nerve from the vascular sheath and injecting it with alcohol without traumatizing the tissues.

3. *Terminal cutaneous trunk of superficial peroneal nerve.* Block of this nerve produces anæs-

tesia of entire dorsal surface of ankle and foot with exception of area at the junction of great and second toes (deep peroneal nerve) and lateral side of foot and little toe (sural nerve) (Figs. 5 and 6).

The superficial peroneal nerve penetrates the deep fascia over the crest of the fibula 6 inches above the ankle. It is purely sensory from this level down. To secure anæsthesia of the dorsal half of the foot with the first and second toes, the deep peroneal nerve must be blocked as well as the cutaneous branch of the peroneal. Both nerves can be exposed through the incision described for the deep peroneal, whereas if the terminal peroneal alone is to be blocked, the incision is more conveniently made three-quarter inch medial to the crest of the fibula (Fig. 10, A). The nerve is found at this level either just above or just beneath the deep fascia (Fig. 4). As seen in Figure 6, the nerve divides into a medial and lateral cutaneous branch. Care must be taken that the nerve is blocked above its point of division or that both branches are injected, if complete anæsthesia over its area of distribution is desired.

4. *Deep and superficial peroneal nerves.* In case it is deemed advisable to block both the deep and superficial peroneal nerves, a very satisfactory exposure is obtained by making a 2-inch incision just below and medial to the head of the fibula. At this level, the common peroneal nerve will be found dividing into its two branches in the substance of the extensor digitorum longus muscle. The fibers of this muscle may be split and the sensory branches of the two nerves isolated by local stimulation, injected with novocain, the area of anæsthesia in the foot tested by peripheral stimulation and alcohol injected in the usual manner, care being used to see that before this step is taken, no muscular paralysis has resulted from the novocain injection. All of the important muscular branches of these two nerves are usually given off above a level of 2 inches below the head of the fibula. It is frequently of assistance to expose the superficial peroneal nerve as previously described at the midleg before both nerves are exposed below the head of the fibula. The sensory branch of the superficial peroneal nerve may then be more easily isolated from its muscular branches.

5. *Sural nerve.* Block of the sural nerve results in anæsthesia over the posterolateral quadrant of leg and lateral portion of foot to fifth toe (Figs. 2 and 7).

The sural nerve is made up of the external saphenous branch of the posterior tibial and the peroneal anastomotic nerves. These unite in the midleg to form the single sural trunk which runs down beneath the lateral malleolus to the little toe.

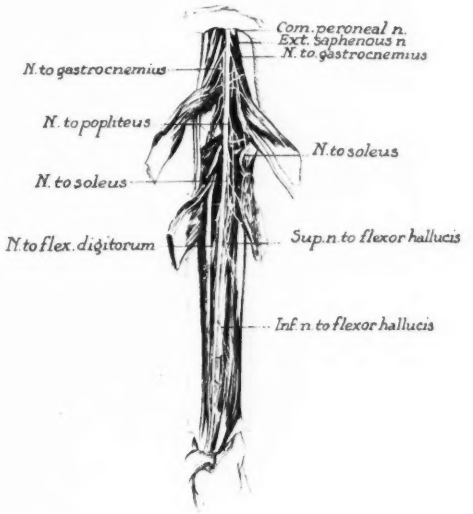


Fig. 3. Dissection of the lower leg to show the course and motor distribution of the posterior tibial nerve. Note that the inferior branch to the flexor hallucis longus is the only motor nerve given off below the midleg. From Havelocque's *Anatomie des nerfs craniens et rachidiens et du systeme grand sympathique.* Gaston Doin et Cie, Paris, 1927.

If anæsthesia of the lateral portion of the foot alone is desired, the nerve may be picked up at a point 6 inches above the ankle where it lies on the deep fascia just lateral to the midline and close to the external saphenous vein (Fig. 5).

If anæsthesia of the posterolateral quadrant of the leg is sought, the two branches must be blocked separately just below the knee. This can be done through the incision shown in Figure 7.

These two nerves may be exposed by a transverse incision 2 to 3 inches below the knee (carried from the edge of the fibula to the midline on the posterior aspect of the leg) or by separate vertical incisions. From our experience with delayed healing in Case 6, we feel that vertical rather than transverse incisions give a better chance of primary union. The position of the nerves is well shown in Figure 8. The external saphenous branch from the posterior tibial is easy to pick up as it lies close to the corresponding vein. Often a terminal branch of the posterior

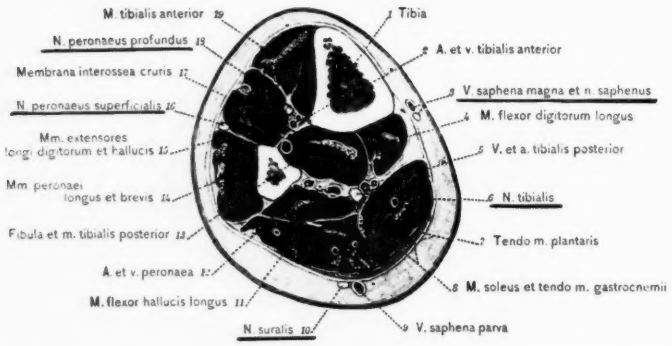

M. tibialis anterior 19
N. peronaeus profundus 18
Membrana interossea cruris 17
N. peronaeus superficialis 16
Mm. extensores longi digitorum et hallucis 15
Mm. peronaei longus et brevis 14
Fibula et m. tibialis posterior 13
A. et v. peronaea 12
M. flexor hallucis longus 11
N. suralis 10
1 Tibia
2 A. et v. tibialis anterior
3 V. saphena magna et n. saphenus
4 M. flexor digitorum longus
5 V. et a. tibialis posterior
6 N. tibialis
7 Tendo m. plantaris
8 M. soleus et tendo m. gastrocnemii
9 V. saphena parva

Fig. 4. Cross section at junction of middle and lower thirds of leg to show position of nerves. From Eycleshymer & Shoemaker's *Cross Section Anatomy*. D. Appleton Co., 1911.

femoral cutaneous overlaps this region. It should be looked for and blocked, if anæsthesia of the upper calf is to be produced.

The peroneal anastomotic branch is harder to find as there is no good landmark, but by searching the tissues both superficially and beneath the deep fascia from the midline to the posterior edge of the fibula, it cannot very well be missed. In a high incision, care must be exercised not to mistake the thick common peroneal nerve for its small anastomotic branch.

6. *Internal saphenous nerve.* Block here causes anæsthesia of the posteromedial quadrant of the leg and medial aspect of the proximal half of the foot (Fig. 1).

This nerve lies close to the internal saphenous vein throughout its entire length in the lower leg. When incision is made just below the knee the nerve lies beneath the deep fascia (Fig. 8). Lower down it penetrates the fascia and lies beside the vein (Fig. 4).

7. *Anæsthesia of the thigh.* As chronic painful ulcerations are rare conditions in the thigh, we have not gone into the technique of nerve injection here in detail. However, it is very easy to block the purely sensory posterior and lateral femoral cutaneous nerves and obtain an anæsthesia of two-thirds of the thigh. While it is feasible to block individually many of the small sensory branches of the anterior crural nerve, it would be impossible to obtain a complete anæsthesia of the anterior third of the thigh without producing paralysis of the quadriceps group of muscles.

CASE HISTORIES

Case 1. L. R. aged 39 years, Jewish, was a victim of thrombo-angiitis obliterans. He entered the hospital in May, 1928, complaining of a painful gangrenous ulcer f right great toe. The patient was treated expectantly f r 2 months. In the hope of increasing circulation and f possibly relieving pain, a lumbar ramisectomy was p - formed on August 1. Following this the patient was ab e to sleep a little, but still could not tolerate Dakin's sol - tion. The toe was then disarticulated on August 15. Th s left a sloughing necrotic stump which showed no tenden y to heal and was so painful that Dakin's solution could n t be tolerated. As the pain was localized to the sole of th e foot, it occurred to one of us (R.H.S.) that blocking th e posterior tibial nerve with alcohol would give the necessar y local anæsthesia. This was done November 17. The pai then disappeared completely, thorough Dakinization of th e stump was instituted, and the sloughing ulcer healed in 2 months.

Case 2. F. W. McE., aged 36 years, Irish, suffered fro thrombo-angiitis obliterans.

In March, 1927, patient first noticed pain and discolora - tion of the first three toes in the right foot. He was carrie along with local treatment and intravenous injections of typhoid vaccine until November, 1928. Then the grea toe became discolored and ulcerated under the nail. Th tip of the toe became acutely tender so that he was unable to sleep and requested amputation. Instead the posterio tibial nerve and cutaneous branch of the peroneal were blocked. The pain stopped from this moment. Disarti - ulation of the toe and medial drainage of its flexor tendons and plantar fascia had to be performed 6 weeks later. Th s incision healed in 2 months, since which time the extremit has been painless, and the patient has returned to hi s former occupation.

Case 3. A. G., aged 36 years, French-Canadian, suffere with thrombo-angiitis obliterans. He entered the hospit l in November, 1928. Fourteen weeks previously he fra - tured his third toe which turned gangrenous and had bee removed a month before entry. He now had a septic stum and gangrene of the second toe. On December 3, this w removed and the plantar fascia drained by removing th distal portions of the second and third metatarsals.

The pain at night and on dressing the sloughing woun became unbearable. On December 17 this portion of t foot was desensitized by blocking the anterior and posteri tibials and the cutaneous branch of the peroneal ner (Fig. 9). He had been so worn out by lack of sleep th he slept nearly the entire following day. In this case aga

Fig. 5. Photograph of leg in Case 5. Posterior tibial nerve exposed and injected through the medial incision, anterior tibial and cutaneous portion of peroneal nerve through the lateral incision. Anterior tibial anæsthesia shown by stippled area. The lateral division of the peroneal nerve was not injected and therefore the dorsal surfaces of the fourth and fifth toes are not desensitized.

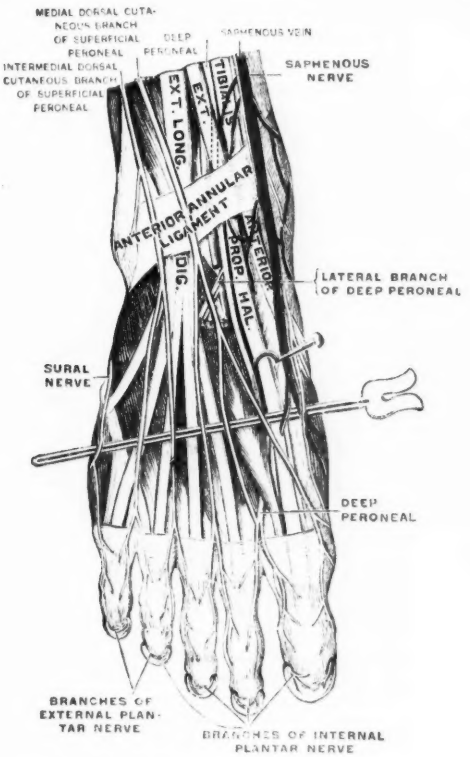


Fig. 6. Nerves of the dorsum of the foot. From Gray's *Anatomy*, 1918 edition, Lea and Febiger.

local dressings could be performed with complete immunity from pain and the sluggish necrotic tissues began to show signs of active healing within a few days.

The wound was practically healed and he was walking in 6 weeks. At present, 3 months after operation, the nerves are regenerated (with the exception of the distal 2 inches of the posterior tibial) and the patient is back at work.

Case 4. J. K., aged 43 years, native, had Monkeberg's sclerosis. In 1918 his right great toe was amputated for gangrene. In 1927 the foot became involved and a Gritti-Stokes amputation was done. In September, 1928, he began to notice intermittent claudication of the left leg. He entered the hospital on December 5 with gangrenous ulcers at the tips of the first three toes. The foot was dusky red and the pain so severe that he asked for amputation at once, but it was decided to make a final attempt to save his remaining leg and the painful toes were desensitized by blocking the posterior tibial and cutaneous peroneal nerves. It was noticed at operation that the posterior tibial artery was thrombosed and that there was practically no collateral circulation. As the gangrene involved only the tips of the toes, the anterior tibial nerve was not injected. This was a mistake, as the gangrene slowly spread down the great toe. Within 10 days he began to complain of pain at the base of his great toe and amputation of the leg became unavoidable.

Case 5. M. H., aged 70 years, Jewish, had arteriosclerotic gangrene. Generalized arteriosclerosis with dusky redness and burning pain was present in first three toes of his right foot. The painful area in the foot was desensitized by alcohol injection of both tibial nerves and the cutaneous branch of the peroneal. It was obvious at operation that the blood supply to the foot was almost completely shut off. The pain was entirely relieved, but 2 weeks later the foot was definitely becoming gangrenous and had to be removed by a Gritti-Stokes amputation.

Case 6. M. S., aged 70 years, Jewish, had arteriosclerotic gangrene. This patient had general arteriosclerosis and an ulcerated area an inch in diameter on the posterolateral quadrant of the lower leg (Fig. 7). No amount of local treatment or Buerger's exercises would induce the ulcer to heal and it became so painful that the old man was reduced to a condition of chronic invalidism. The pain was relieved by picking up the medial and lateral trunks of the sural nerve and cutting them below the knee. As permanent anæsthesia was necessary, 2 centimeters of each nerve were excised instead of the usual injection with alcohol. The incision became slightly septic and healed by second intention. At the end of 2 months it was healed and the ulcer itself was 50 per cent smaller. At the end of 3 months the ulcer had healed.

Case 7. M. S., aged 67 years, Jewish, had arteriosclerotic gangrene. This was the case of another old man with a deep, painful ulcer of the outer surface of the little toe. X-ray picture showed marked calcification of the arteries and osteomyelitis of the metatarsophalangeal joint. No pulsation could be made out in the vessels of either foot, but the popliteal arteries were patent. To relieve his pain

Fig. 7. To show transverse incision used to expose the two trunks which make up the sural nerve with the resultant anæsthesia of the lateral aspect of the leg and foot. Case 6.

the posterior tibial and cutaneous branches of the peroneal nerve were exposed and injected with alcohol. The toe was then disarticulated and the open stump Dakinized. Pain was completely relieved; sensation, however, in the most proximal and lateral part of the incision remained, as this region is supplied by the sural nerve. The patient was then able to tolerate thorough Dakinization and the wound was slowly healing when he was discharged from the hospital.

Case 8. E. M., aged 72 years, native, had arteriosclerotic gangrene. One month previously this man had undergone a Gritti-Stokes amputation of his left leg. When he began to walk a septic blister formed on the inferior lateral aspect of his right big toe. The dead skin was cut away, revealing a necrotic base which was acutely painful. Following the procedure recommended by Sampson-Handley and McClintic, 95 per cent alcohol was injected beneath the adventitia of the femoral artery in the midthigh. This produced no improvement in the circulation of the foot and he proceeded to develop a new ulcer on the lateral aspect of his heel. The periarterial injection did give a partial relief of pain for 5 days, but it then recurred with full severity, and we were forced to intervene again; either by blocking the pain or amputating his remaining leg. The pain in the toe was desensitized by alcohol injection of the posterior tibial and the terminal sensory trunk of the peroneal nerve. This anæsthetized the toe and the sole of the foot, all but a small zone on the inferior lateral aspect of the heel, where the second ulcer was situated. This could have been desensitized by blocking the sural nerve, but as a third ulcer was appearing on the knee, the leg was finally amputated through the lower thigh.

Case 9. W. G., aged 62 years, had arteriosclerotic gangrene. The patient had been suffering from the pains of intermittent claudication for 2 years. Three weeks before admission he developed a painful ulcer on the outer surface of his little toe, from which burning pain radiated through the dorsum of his foot. No arteries were palpable below the main femoral in the groin.

After warning the patient that there was only the smallest hope of saving his foot, the pain was relieved by blocking the posterior tibial and the superficial peroneal nerves at the midleg (2 inches higher than the usual level on account of the extremely poor circulation). No bleeding points were encountered. Within 10 hours it was noticed that the gangrenous patch on the fifth toe was extending and on the next morning the distal half of the foot was quite definitely gangrenous. A Gritti-Stokes amputation was performed. Dissection of the leg showed the popliteal and anterior tibial arteries to be completely occluded by old organized thrombi. The posterior tibial artery was like a pipe stem, but open below the point of operation. Even after dissection of the leg it is difficult to account for the rapid spread of gangrene, nevertheless this complication must be put down against our operative interference.

This is the only instance in our series where the procedure seems to have caused a sudden increase of gangrene. Perhaps it was bad judgment to attempt anything short of primary amputation in a leg with such a marked impaired circulation; but in any event the amputation healed by first intention and the patient's hospital stay was only prolonged five days for the attempt.

Case 10. W. P. W., aged 43 years, native, had thrombo-angiitis obliterans. Two years ago the patient had his left leg amputated because of uncontrollable pain in two small patches of superficial gangrene on his first and third toes. Four months ago he returned to our clinic with his remaining foot cold, cyanotic, and beginning to ulcerate on the outer surface of the great toe. In spite of exercises and injections of foreign protein to increase circulation, the ulcer became steadily larger and more painful. Through injection of the posterior and anterior tibial nerves, as well as the terminal sensory trunk of the peroneal,[1] the pain was completely relieved. A month later the foot remained entirely free from pain, but quite unable to increase its collateral circulation enough to heal the ulcer. We were, therefore, forced into doing a Gritti-Stokes amputation. This is the first instance in which amputation has as yet been necessary in the cases of thrombo-angiitis obliterans, after the pain factor has been eliminated. Dissection of the leg showed almost complete obliteration of the main vessels from the knee down and a very poorly developed collateral circulation.

Case 11. L. S., aged 37 years, Jewish, had thrombo-angiitis obliterans. The first symptoms of the disease appeared 10 years ago, with recurring ulcerations over the past 6 years. Three years ago he was forced to stop work on account of pain. During all this period he has been treated by men experienced in the disease with exercises, injections of Ringer's solution, and foreign protein. None gave relief. A few months ago he fell into the hands of a "faith-healer" who applied leeches. Each leech formed an ulcer and the ulcers coalesced into a single large one on the dorsum of his foot. The end of the big toe became gangrenous at the same time, so that he entered the hospital in intense pain and prepared for immediate amputation (Fig. 10A). The ulcers were extremely dirty, as only a thick greasy ointment could be tolerated.

In this case we were forced to block the sural as well as the posterior tibial and peroneal nerves. There was an extraordinarily rich collateral circulation in the subcutaneous tissue, but the posterior tibial artery and vein were completely obliterated in a mass of scar tissue which was densely bound to the nerve. As we felt that the anterior

[1] In the first attempt to desensitize the dorsum of the foot, a well defined nerve trunk was exposed in the usual position of the superficial peroneal nerve in the lower third of the leg. Following its injection anæsthesia extended only over the proximal half of the foot. Complete anæsthesia was produced by a second later incision, exposing the nerve over the upper end of the fibula, and injecting its trunk just beneath the point of origin of its main motor branches.

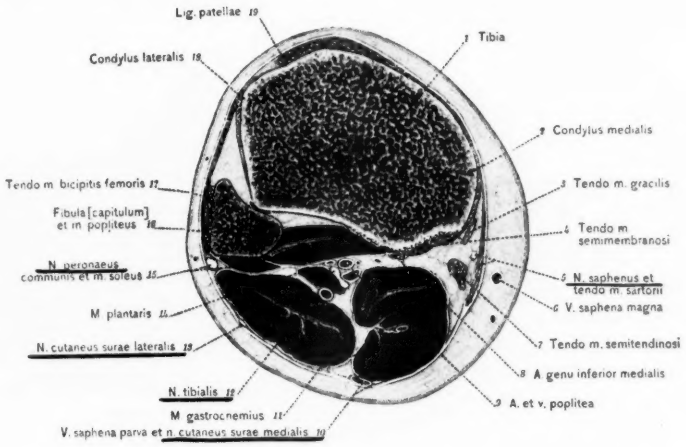

Lig. patellae 19
Condylus lateralis 18
1 Tibia
2 Condylus medialis
3 Tendo m. gracilis
4 Tendo m. semimembranosi
5 N. saphenus et tendo m. sartorii
6 V. saphena magna
7 Tendo m. semitendinosi
8 A. genu inferior medialis
9 A. et v. poplitea
Tendo m. bicipitis femoris 17
Fibula [capitulum] et m. popliteus 16
N. peronaeus communis et m. soleus 15
M. plantaris 14
N. cutaneus surae lateralis 13
N. tibialis 12
M. gastrocnemius 11
V. saphena parva et n. cutaneus surae medialis 10

Fig. 8. Cross section at level of incision in Figure 7 to show position of lateral and medial sural trunks. From Eycleshymer and Shoemaker's *Cross Section Anatomy*. D. Appleton Co., 1911.

tibial nerve would be equally difficult to expose and that too much surgery should not be done at one time, this nerve was not blocked.

As a result of these injections, the dorsum and sole of the foot became completely anæsthetic (Fig. 10A and B). Only a small area deep in the first toe, where the distal phalanx was removed, remained sensitive (supplied by the uninjected anterior tibial nerve). The ulcers cleaned up rapidly under Dakin's regimen and were covered with "small deep grafts" (Davis) 2 weeks after the sensory nerves were blocked. Apparently one of the large, subcutaneous arterioles cut in exposing the sural nerve was an "end artery," as an area of discoloration appeared in the outer edge of the sural nerve incision and formed a slough 2 by 4 centimeters. The other two incisions healed by first intention. A month later the anterior tibial nerve was also blocked, as pain persisted deep in the big toe when he began to walk. He now (1 week later) has no sharp pain, but tingling and prickling sensations persist when he hangs the foot down. This is probably caused by the blood distending the arterioles in the foot and must be referred over the periarterial sympathetic nerves, as the foot is otherwise completely anæsthetic.[1]

All the patients in this series were on the verge of amputation; primarily because of pain, secondarily on account of advancing gangrene or infection. As a last hope, nerve injections with alcohol were performed to allow the patients to sleep and thereby improve their general condition and to prevent them from becoming morphine addicts. From the viewpoint of local treatment, anæsthesia of the painful area permitted adequate Dakinization and the free cutting away of necrotic tissue.

[1] These sensations disappeared completely after he began to walk.

In five instances the gangrene continued to extend and amputation became inevitable, but these were extreme cases with complete occlusion of the main vessels and almost no collateral circulation. In one such case, operation seems to have precipitated a sudden thrombosis with widespread gangrene of the foot. Dissection of this leg after amputation showed no apparent operative cause for this sudden increase in gangrene (Case 9).

In reviewing the entire series on the bases of patency of the main vessels in the lower leg (Table II), it at once becomes apparent that 5 out of 7 cases with obliteration of the popliteal arteries have gone on to eventual amputation, whereas in all the ones in which this vessel could be felt pulsating the leg has been saved. Hereafter, when confronted with a painful threatened gangrene of the toes plus a thrombosed popliteal artery, we shall warn the patient that the ultimate chance of saving his leg is extremely small.

In the 5-year period preceding the institution of this method of treatment, there have been 24 amputations in cases of thrombo-angiitis obliterans. The records of 12 of these cases indicate that pain was either the chief cause for amputation or indirectly probably a cause in that the extremity was too painful to permit adequate conservative treatment. Five of the unamputated cases were discharged without relief of pain. Since the beginning of this work,[2] 14 cases have been under

[2] These statistics were looked up for us in the Massachusetts General Hospital records from May 30, 1923, to November 13, 1928, by Dr. A. Graybiel.

Fig. 9. *A*, Anæsthesia produced by alcohol injection of anterior tibial and medial cutaneous branch of peroneal. *B*, Incision for blocking posterior tibial nerve and resultant skin anæsthesia. Note that there is a narrow strip along the lateral edge of the sole and heel which is not desensitized. This is supplied by the sural nerve. Case 3.

Fig. 10. Anterior view of leg showing incision f injection of both branches of cutaneous peroneal nerv the ulcer on the dorsum of the foot, and the big toe di articulated at its interphalangeal joint. After the anteri tibial nerve was blocked at the second operation, anæsthesi was complete below the black line. *B*, Posterior vie showing incisions for blocking posterior tibial and sura nerves. Ischæmic necrosis of skin lateral to sural incision Below the black line the leg and foot are completel anæsthetic, as all the nerves have been blocked excep the saphenous. This nerve was presumably cut acros in making the posterior tibial incision. Case 11.

treatment, 5 have required operative relief of pain. and only 1 has been amputated.

In the arteriosclerotic group the results are not nearly as favorable—in the 6 which have required sensory nerve injection for pain, only 2 have avoided amputation.

This is undoubtedly due to the fact that they do not develop as efficient a system of collateral circulation and that the disease more frequently obliterates the vessels above the knee.

We feel that the legs in 6 out of this series of 11 patients were quite definitely saved through desensitization and rendering the septic gangrenous areas susceptible to intensive local treatment. Six of these patients are now walking about with no sign of impaired function of the feet or any tendency to trophic lesions. In Case 3, nerve regeneration was nearly complete at the end of 3 months, whereas in Case 1 at the end of 5 months the entire sole of the foot was still anæsthetic.

It may seem surprising that the operative incisions healed by first intention in the great majority of cases, even when the foot ultimately went on to gangrene and amputation. We believe, however, that healing of small vertical incisions can ordinarily be counted on, as in cases of the most advanced arterial obliteration, the skin temperature usually becomes normal at the junction of the middle and lower thirds of the leg.

We recommend that pain be relieved early in the treatment of these cases. Other conservative procedures are much more effective in the absence of pain.

It is impossible for a patient to do adequate postural exercises in the presence of intolerable pain, and we consider this an important adjunct to the treatment of such cases. The same applies to externally applied heat such as an electrically heated cradle. Sepsis is often an important factor. One cannot control sepsis when the patient cannot tolerate Dakin's solution and frequent dressings. Operations on peripheral vessels and the sympathetic nervous system designed to stimulate the circulation may relieve pain as shown by Leriche and Archibald; in many instances, however, the relief from pain is insufficient or of short duration.

In closing, we wish to emphasize again that most patients with painful ischæmia of the feet are entitled to this ultimate conservative procedure, especially if they have already lost a leg (Cases 4, 8, and 10). It involves little risk and only a slight, very justifiable, delay if unsuccessful.

CONCLUSIONS

1. Pain in the lower legs and feet secondary to obliterative vascular disease can be relieved by alcohol injection of peripheral nerves.

TABLE II.—PATENCY OF ARTERIES

Case No.	Arteries			Pain after operation	Amputation of leg	Disease
	Popliteal	Dorsalis pedis	Post tibial			
1	▫	○	○	○	○	Thrombo-angiitis obliterans
2	○	○	○	○	○	Thrombo-angiitis obliterans
3	┼	○	○	○	○	Thrombo-angiitis obliterans
10	┼	○	○	○	○	Thrombo-angiitis obliterans
11	○	○	○	○	┼	Thrombo-angiitis obliterans
4	○	○	○	○ (*)	┼	Monkeberg sclerosis
5	○	○	○	○	┼	Arteriosclerosis
6	┼	○	○	○	○	Arteriosclerosis
7	┼	○	○	○	○	Arteriosclerosis
8	▫	○	○	○ (†)	┼	Arteriosclerosis
9	○	○	○	○	┼	Arteriosclerosis

*Subsequent extension of painful gangrene into an unblocked area.
†Relief of pain complete except in unblocked area on outer side of heel.

2. This can be accomplished without paralysis of any important muscles of the leg or foot.

3. Careful operative technique and scrupulous asepsis are essential to success.

4. A serious slough may be precipitated by spilling alcohol into the tissues.

5. Incisions should be made above the lower third of the leg and should be vertical by preference. They usually heal by first intention.

6. Depending on the length of nerve trunk injected, the anæsthesia produced may last but a few months or may be permanent.

7. The relief of pain has been responsible for the saving of 6 out of 11 legs otherwise doomed to amputation.

8. It should never be necessary to sacrifice a leg because of pain.

9. After an extremity has been desensitized by this method we have noticed frequently that the foot becomes drier, warmer, and that previous color changes are eliminated. The surface temperature may rise 5 degrees F. This is probably due to elimination of sympathetic stimulation both by relieving pain and by interrupting the course of the nerve fibers to their peripheral destinations. The majority of the sympathetic nerves course peripherally with the sensory nerves.

10. The result is much more apt to be successful if the popliteal artery pulsates. In cases of senile arteriosclerosis with arterial obliteration above the popliteal vessel, this procedure, even if done in two or three stages, may precipitate actual gangrene and hasten amputation. We feel, however, that, in such a case if amputation is necessary anyway because of pain, one is justified in desensitizing the extremity first.

11. After an extremity has been desensitized, ulcerations which previously resisted all methods of treatment will frequently heal.

BIBLIOGRAPHY

1. Adson, A. W., and Brown, G. E. Raynaud's disease of the upper extremities: successful treatment by resection of the sympathetic cervicothoracic and second thoracic ganglions and the intervening trunk. J. Am. M. Ass., 1929, xcii, 444–449.
2. Allen, A. W. Periarterial sympathectomy. Boston M. & S. J., 1924, cxci, 390–395; End-result studies on circulatory diseases of the extremities treated by periarterial sympathectomy. Boston M. & S. J., 1927, cxcvii, 304–309.
3. Allen, A. W., and Smithwick, R. H. Use of foreign protein in the treatment of peripheral vascular diseases. J. Am. M. Ass., 1928, xci, 1161–1168; The treatment of vascular lesions of the extremities. J. Michigan State M. Soc., 1929, pp. 38–42; Thrombosis of peripheral arteries following the intravenous injection of typhoid vaccine. New England J. Med., 1929, cc, 217–219.
4. Archibald, E. Effect of sympathectomy upon the pain of organic disease of arteries of the lower limb. Ann. Surg., 1928, lxxxviii, 499–509.
5. Brown, G. E. Treatment of peripheral vascular disturbances of the extremities. J. Am. M. Ass., 1926, lxxxvii, 379–383.
6. Corlette, C. E. A rapidly curative operation for irritable ulcer of the malleolus. Surg., Gynec. & Obst., 1929, xlviii, 811–816.
7. Handley, W. Sampson. The treatment of gangrene. (Paper read before the British Medical Association, July, 1928.)
8. Leriche, R. Some researches on the periarterial sympathetics. Ann. Surg., 1921, lxxiv, 385–393.
9. Lewis, Dean. Spontaneous gangrene of the extremities. Arch. Surg., 1927, xv, 613–626.
10. McClintic, C. F. Treatment of trophic ulcers by alcohol injection of the blood vessels. J. Am. M. Ass., 1929, xcii, 956–958.
11. Morton, J. J., and Pearse, H. F. Temperature effect of popliteal vein ligation in thrombo-angiitis obliterans and arterio-sclerosis. Ann. Surg., 1928, lxxxviii, 233–240.
12. Oppel, F. Die wietingsche Operation und der reducierte Blutkreislauf. Abstracted in Centralbl. f. Chir., 1913, xl, 1241.
13. Silbert, S. A new method for the treatment of thrombo-angiitis obliterans. J. Am. M. Ass., 1922, lxxix, 1765.

INTRAVENOUS UROGRAPHY[1]

HERMAN L. KRETSCHMER, M.D., F.A.C.S., CHICAGO
From The Presbyterian Hospital of Chicago

THROUGH the kindness of Professor von Lichtenberg of Berlin, it has been my good fortune to use uroselectan[2] in a series of 85 cases. My experience with this drug, after administering it to adults of both sexes and to children, bear out the claims made for it, that it is non-toxic and non-irritating. In our series of cases, the injections were without local reactions and without local pain except in one or two instances; they were also without systemic reactions such as chills and fever. Some of the patients complained of a feeling of thirst and a sense of warmth which occasionally was associated with a flushed condition of the face and head, but these symptoms were transitory and disappeared very rapidly.

In a series of 10 cases in infants and children, the tolerance for uroselectan was particularly good. In these patients also systemic reactions were lacking; hence it is evident that, as a diagnostic aid, uroselectan is of great importance prior to cystoscopy in children. In 4 of these 10 cases excellent urograms were obtained after the injection of uroselectan. In one case two injections were given and no urogram was obtained. Death occurred 21 days after the second injection. This death was in no way associated with the injection, for at autopsy the kidneys were found to be the seat of very extensive destructive disease, which explained their failure to eliminate the drug. The blood chemistry before injection was: non protein nitrogen, 84; uric acid, 8.6; creatinin, 2.0.

Congenital anomalies were easily demonstrated by means of uroselectan injection. In our series bifid pelves were readily shown in several instances, as was also a horseshoe kidney in one case. In the case of a solitary kidney with a stone in the pelvis on one side, no shadow was obtained on the opposite side, and cystoscopic examination and chromocystoscopy failed to show the presence of a left ureter. The diagnosis of solitary kidney in this instance was verified by operation and the stone was removed.

In one case of polycystic disease of the kidneys, the intravenous pyelograms, while readable, were not as clear cut as were the pyelograms made with ureteral catheters from below.

The best—that is the most easily readable—pyelograms and ureterograms, obtained in the regular routine, were in cases of hydronephrosis and hydro-ureters. In cases of unilateral involvement, it was found that the side affected stood out in marked contrast to the normal side.

In the presence of renal and ureteral calculi, the intensity of the shadow was sometimes increased by the drug. In ureteral stone, the use of uroselectan readily demonstrated whether the stone had caused a complete obstruction—a point of great value as an aid in determining whether the patient should be operated upon at once or whether, because the urine passes by the stone, delay is justifiable until the stone has progressed downward, aided or unaided by cystoscopic manipulations. In such cases the renal shadow on the affected side is much more clearly outlined than on the normal side; just as though the uroselectan had reached the kidney but that it was not being eliminated. Failure to show the outlines of the ureters when there was fluid in the pelvis of the kidney and in the bladder was due to the absence of obstruction and normal, or possibly hyperactive, ureteral peristalsis.

Because of the rapid elimination of the drug and its collection in the bladder, it is advisable to drain the bladder with a catheter in those cases in which study is directed toward the lower end of the ureter. The rapid disappearance of dilatation of the ureter following the passage of stones and also following dilatation of strictures can be satisfactorily shown by means of the drug.

Great care must be exercised in some of the very early lesions of tuberculosis and tumor. In renal tuberculosis uroselectan has given satisfactory results particularly in the group of cases in which, for various reasons, ureteral catheterization is impossible. Likewise it is a relatively simple means of investigating the remaining kidney inasmuch as pyelograms are available without catheterization of the ureter of this remaining kidney.

In malignant tumors of the kidney filling defects have been shown and a diagnosis of kidney tumor made. If great destruction of kidney tissue by the tumor has occurred the intravenous pyelograms are not so clearly defined as in pyelograms made from below. At times it is advisable to check with a retrograde pyelogram.

[2]Placed at my disposal through the courtesy of the Schering Corporation of New York.

[1]Submitted for publication July 7, 1930.

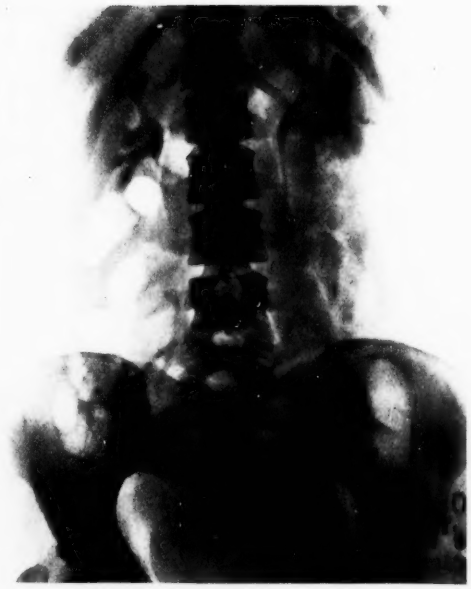


Fig. 1. Normal pyelograms. Intravenous pyelograms were made to determine the origin of pain in the right upper quadrant.

Fig. 2. Intravenous pyelograms were made to determine the origin of a large movable tumor in the right upper quadrant. Pyelograms, normal. The tumor was due to an enlarged gall bladder.

Fig. 3. Congenital solitary kidney with stone. Complete absence of shadows on the left side.

Fig. 4. Showing a moderate hydronephrosis on the right side and rotation of the kidney on the left side.

Fig. 5. Bilateral hydro-ureters and hydronephroses are clearly shown.

Fig. 7. Bilateral dilatation of ureters which is due to the presence of ureteral calculi.

Fig. 6. Moderate dilatation of right ureter, kidney pelvis, and calyces due to stone in the pelvic ureter. Left kidney, normal.

Fig. 8. Obstruction in right ureter due to stone in the lumbar ureter, with dilatation of the ureter and kidney pelvis. Left pyelogram, normal.

Fig. 9. Stone in right ureter. Note absence of fluid in right kidney pelvis and right ureter, due to unilateral suppression. Left pyelogram, normal. Shadow of kidney has been intensified by the drug.

Fig. 10. Tumor (hypernephroma) of left kidney showing collection of fluid at lower margin of kidney and calcification just below the last rib. Pyelogram on the opposite side, normal.

Fig. 11. Tumor of the left kidney. Right pyelogram and right ureter, normal. Only a faint trace of fluid in the left kidney. Compare with Figure 12.

Fig. 12. Tumor of the left kidney. Pyelograms made from below. Compare with Figure 11; note the difference. This shows the pelvis compressed, elongated, and displaced.

Fig. 13. Failure to obtain left pyelogram due to destruction of kidney by tuberculosis. Evidence of involvement of opposite ureter and kidney.

Fig. 14. Intravenous pyelography. Normal pyelograms. Cystogram shows a filling defect due to a carcinoma of the bladder.

Problems of interpretation will naturally arise just as with any other new diagnostic procedure. Nevertheless, with our present knowledge of interpretation, based on the reading of pyelograms made from below, in addition to the fact that doubtful cases can be checked with pyelograms made in this way, and with increasing experience gained in reading urograms made with uroselectan, the problems involved in correctly interpreting the "picture" will necessarily become less and less until finally, in my opinion, they will be negligible.

This method may serve as a check on retrograde pyelograms. In one instance a diagnosis of complete obstruction was made, based on the fact that the catheter was arrested at the brim of the pelvis and a pyelogram could not be obtained from below. An intravenous pyelogram made the next day revealed a normal pyelo-ureterogram.

I have also used this new drug as a medium for making pyelograms from below, diluting the standard solution (as used for intravenous injection) with equal parts of water. The advantages of making pyelograms with this drug from below are that the pictures are beautifully clear cut, the drug is non-irritating, and there results practically no reaction from its use.

In determining the origin and location of obscure abdominal pain and in differentiating lesions of right upper quadrant and spleen, this new diagnostic procedure has been of great help.

Finally, it should be emphasized that even though the desired data have been accumulated from the standpoint of the pyelograms, it is still necessary, before surgical procedures are carried out on the kidney, to examine the patients with the cystoscope, to catheterize the ureters, to carry out the usual careful examinations to determine the presence of pus and blood, to make bacteriological studies for infection—making stains for tubercle bacilli and guinea-pig tests, and to ascertain the differential function of the kidneys.

INTRAVENOUS UROGRAPHY IN THE DIAGNOSIS OF UROLOGICAL DISEASES IN CHILDHOOD[1]

ABRAHAM HYMAN, M.D., NEW YORK
From the Surgical Service of Dr. Edwin Beer, Mt. Sinai Hospital

THE study of urological diseases in childhood, which has received considerable attention in the past 5 years, will no doubt gain added impetus through the introduction of the new intravenous pyelographic medium, uroselectan, recently introduced by Swick. This method of examination will prove an even greater boon in its application to children than it offers to adult urology, and will add considerably to our diagnostic accuracy. Here we have a means of visualizing the urinary organs and at the same time obtaining information as to the function and dynamics of the tract without resorting to instrumentation. Uroselectan may be used at all ages and requires no anæsthetic, thus obviating one of the disadvantages of retrograde pyelography in children. Roentgenograms taken under anæsthesia are often blurred, and the kidneys are incompletely distended as it is then impossible to judge the proper amount of solution to inject in order to fill the pelvis. All of these disadvantages have been overcome by intravenous pyelography, which, in a series of 22 cases ranging in age from 6 months to 12 years, has been found to be absolutely non-toxic.

A few words as to the historical development of intravenous pyelography: In 1923, Osborne, Sutherland and Scholl, and Rowntree first attempted visualization of the urinary tract with iodides administered both orally and intravenously. Their results did not warrant its adoption as a routine clinical measure. Since then various contributions have been made by Rosenstein, von Lichtenberg, Volkmann, Lenardouzzi, Pecco, Hryntschak, and Ziegler and Koehler. Roseno[2], in 1929, obtained practical results associated, however, with some reactions, reporting excellent visualization of the urinary tract by means of a solution combining sodium iodide and urea. Finally Swick,[3] a few months later, introduced the preparation known as uroselectan. In a subsequent paper by von Lichtenberg and Swick,[4] the clinical application of this drug was described in detail.

The work on uroselectan was begun by Swick with selectan neutral, both being synthesized by Professor Binz and Dr. Raeth on the medical service of Professor Lichwitz in Altona, Germany. The original preparation caused some untoward symptoms, and was modified to obviate some of its toxicity. The final preparation (that now called "uroselectan") we have used on the service of Dr. Beer at Mount Sinai Hospital, in collaboration with Dr. Swick, in more than 100 cases, both adults and children, without ever having noted any unpleasant manifestations after its administration.

Uroselectan is an iodine-pyridin combination with an iodine content of 42 per cent. It is absolutely non-toxic, neutral in reaction, readily soluble in water, and its tolerance is exceedingly great. As a result, intravenous urography has been placed on a practical, every day working basis. Since visualization with uroselectan depends upon the functional activity of the kidney, we have in this method a roentgenological functional test, in addition to a way of gaining information as to the dynamics of the urinary tract. Aside from outlining the pelves, ureters, and bladder, the kidney shadow itself is intensified so that it stands out in relief. Lack of visualization may mean either a non-functionating kidney, temporary inhibition, or absence of the organ. The functional value of intravenous urography can also be determined by the estimation of the substance excreted in the urine. Under normal conditions, 95 per cent should be excreted within 6 to 8 hours. About three-fifths of the substance is excreted during the first 2 hours, one-quarter during the next hour, and the remainder in another 4 hours. In the case of diseased or damaged kidneys, the rate of excretion is proportionately decreased, and the substance has been found in the urine as late as 6 or 8 days after injection when stasis has been present. The specific gravity of the urine in norma kidneys is greatly increased, often reaching as high as 1040 or 1045 within a few hours after injection, whereas such is not the case in the presence of diseased organs. Studies made on the determination of the iodine component in the blood and the substance excretion in the urine, will be reported fully by Dr. Swick, together with comparative estimations of the usual functional tests (phenolsulphonephthalein, indigo carmine, concentration, and blood chemistry).

[2]Roseno. Klin. Wchnschr., 1929, June 18.
[3]Swick. Klin. Wchnschr., 1929, Nov. 5.
[4]Von Lichtenberg and Swick. Klin. Wchnschr., 1929, Nov. 5.

[1]Submitted for publication June 9, 1930.

Fig. 1. Intravenous pyelogram in a girl 7 years of age. Pyelitis. No demonstrable pyelographic changes.

Fig. 2. Pyelitis in a girl 5 years of age. No change demonstrated by pyelography.

The technique of administration is very simple, and has already been described.[1] A child of 7 years of age receives one-half the adult dose (which is 40 grams), and a patient of 2 years, one-quarter of the dose. The youngest injected in our series was an infant of 6 months. Compression by means of an inflated rubber bag over the bladder region 10 minutes prior to and during the time of roentgenographic exposures, markedly intensifies the pyelograms. It is advisable, however, to take one or two films without compression. The first roentgenogram is taken 15 minutes after the injection, the second 20 to 30 minutes after the first, and the third a corresponding period following the second. Subsequent plates depend on the findings of the first two, and

[1]Swick. Am. J. Surg., 1930, Feb., pp. 405-414.

Fig. 3. Pyelitis in girl 8 years of age. In the right kidney is shown moderate blunting of the calyces.

Fig. 4. Pyelonephritis in girl 13½ years of age. Intravenous pyelogram shows slight blunting of calyces of left kidney.

Fig. 5. Pyelitis in girl 5½ years of age. The roentgenogram shows the right pelvis moderately dilated. A distinct loop is visible in the ureter below the pelvis, with fairly well marked dilatation of the ureter below this point.

Fig. 6. Intravenous pyelogram in a boy 11½ years of age, showing an area of destruction involving the left kidney. Infiltration of parenchyma with pyelographic medium radiating from the middle calyx, suggestive of tuberculosis. Nephrectomy performed and pathological diagnosis was "circumscribed subacute purulent interstitial inflammation."

Fig. 7. Left renal tuberculosis in girl of 9 years. Diagnosis confirmed by nephrectomy.

Fig. 8. Boy 7 years of age. Bilateral transplantation of ureters into sigmoid for ectopia vesicæ. Most of the calyces in both kidneys somewhat blunted. A good deal of solution is seen throughout the entire colon.

Fig. 9. Girl 13 years of age who about 4 years ago had a plastic repair for large hydronephrosis of left kidney. Intravenous pyelogram now shows moderate dilatation of left kidney, with evidences of stasis but good function.

Fig. 11. Intravenous pyelogram showing large congenital dystopic hydronephrotic left kidney in girl 9½ years of age.

Fig. 10. Boy 10 years of age. Pyelogram showing large hydronephrotic right kidney.

Fig. 12. Same patient as in Figure 11 showing more filling of sac and better visualization one-half hour later.

Fig. 13. Congenital hydronephrosis in boy 8 years of age. Exposure made 1½ hours after injection.

Fig. 14. Same patient as in Figure 13, 5¼ hours after injection. Pelvis and calyces more distended and show more intense visualization.

Fig. 15. Same patient as in Figures 13 and 14, 9¼ hours after injection—retention in left, but right fails to visualize.

on the pathological process with which one is dealing. In the presence of any factor resulting in stasis, late plates usually give more information than the early ones.

To what extent intravenous urography will supplant cystoscopic procedures cannot as yet be determined. No doubt in many instances we will be able to dispense with cystoscopic pyelography. Since this test depends on the functional capacity of the kidneys, when there is poor function the intravenous radiograms are usually unsatisfactory and will have to be supplemented by the older method of retrograde pyelography. In renal neoplasms in children, in which the entire kidney is often destroyed by tumor tissue, there is very little or no visualization, and more information from a diagnostic point of view is afforded by the usual method of pyelography. Nevertheless, in this type of case, where there is a definite palpable tumor on one side, cystoscopy may be dispensed with if the other kidney visualizes normally. In pyelitis we have noted a blunting of the major and minor calyces and changes in the ureter outline, corroborating the findings of retrograde pyelography. The method should prove invaluable in the study of congenital anomalies and will no

Fig. 16.[1] Congenital ureterohydronephrosis of left kidney in boy 11 years of age. Intravenous pyelogram taken 25 minutes after injection.

Fig. 17. Roentgenogram taken 3½ hours after injection in same patient as in Figure 16. Shows dilatation of lower end of ureter due to obstructive lesion at ureterovesical junction.

doubt bring to light many unsuspected conditions. In pyonephrotic and hydronephrotic kidneys the visualization will, of course, depend on the amount of functionating kidney parenchyma. This brings up the question of whether or not the functional value of this method bears any relation to the degree of visualization. Our experience would seem to indicate that when there is good visualization, the kidneys are probably functioning normally. Other factors, however (such as stasis, polyuria, roentgenological technique, the preparation of the patient, and obesity) must be taken into consideration, as all of these have their influence on the intensity of the shadows. In stasis due to mechanical causes, the late pictures become more and more intense, and plates taken 6 or 8 hours after injection show more distinctly and give more valuable information than early ones, which is exactly the opposite in normal kidneys.

The field of application of intravenous urography is very broad; and as our experience progresses, the indications will become pretty well standardized. In children it will probably be used more as a routine procedure than in adults. It is of especial value when for one reason or another cystoscopy cannot be performed or the ureters catheterized, in the presence of hæmaturia, and in cases in which the ureters have been transplanted into the bowel. Von Lichtenberg and Swick reported that in 75 per cent of injected cases the pyelogram gave satisfactory diagnostic information, whereas in 25 per cent cystoscopy and retrograde pyelography had to be resorted to for supplemental information.

In the study of these pyelograms our old concepts will have to be revised. For instance, serial roentgenograms of kidneys without any evidences of obstruction almost invariably show filling of the pelves and calyces. One would not expect, under normal conditions, to find this so, as we have been led to believe that the pelvis empties itself before it is completely filled. The injection produces considerable diuresis for a time, which may account in part for this phenomenon. The pictures are not as sharp as those obtained with retrograde pyelography, although in general the pelvis, calyces and ureters are well outlined.

In 22 children injected, reliable diagnostic data was obtained in most instances by intravenous urography alone. It was of particular service in 4 cases in which on account of severe cystitis the ureters could not be visualized. Almost all these children were controlled by cystoscopy, functional tests, and in most instances cystoscopic findings were in accord with the pyelographic

[1]Figures 16 and 17 were loaned me by Dr. Jerome S. Leopold, of Lenox Hill Hospital.

data. In obstructive conditions (hydronephrosis, ureter calculus, etc.), the degree of visualization cannot be entirely depended upon as a guide to the functional impairment of the kidney. Even though considerably damaged, sufficient substance may accumulate in the hydronephrotic sac to render a satisfactory degree of visualization. In the large uninfected hydronephroses, visualization of a normal kidney on the opposite side may be sufficient diagnostic data on which to base operative indications without resorting to cystoscopy. However, in conditions associated with pyuria, it will always be advisable to resort to cystoscopy and ureteral catheterization, even though the pyelogram shows an apparently normal kidney on the other side, as only by this means can we determine the presence of infection. Functional tests should always be made before deciding on intravenous pyelography; if there is poor function with marked blood retention, this procedure should not be used.

In conclusion, it may be stated that intravenous pyelography, especially in urology of children, has already proved to be a most valuable diagnostic adjuvant. It is absolutely non-toxic, and does away entirely with all the disadvantages of retrograde pyelography. It not only opens up new vistas, but will undoubtedly place urological diagnosis on an even more accurate basis than is at present possible. It is an entirely physiological procedure outlining the whole urinary tract and does away with artefacts caused by cystoscopic pyelography. It also settles once and for all the question of simultaneous bilateral pyelography, a procedure which has given rise to considerable adverse criticism during the past few years. Intravenous pyelography offers an excellent method of studying dynamic conditions of the kidneys and ureters, and from observations made so far offers us a radiographic functional test. For the present, until this method has been given a more extensive trial, it would seem advisable to supplement the examination by cystoscopy.

The accompanying illustrations demonstrate various conditions in which intravenous pyelography has been employed.

THE TREATMENT OF IRREDUCIBLE INTUSSUSCEPTIONS IN CHILDREN

A Clinical and Experimental Study[1]

ALBERT H. MONTGOMERY, M.D., and J. J. MUSSIL, M.D., Chicago

From the Otho S. A. Sprague Memorial Institute Laboratory at the Children's Memorial Hospital and the Department of Surgery at Rush Medical College, University of Chicago

ONE of the baffling pathological conditions that may confront the surgeon is an irreducible intussusception. The seriousness of this condition is augmented by the fact that most of them are found in very young children, since 80 per cent of intussusceptions occur in children under 2 years of age. In addition, these young patients are suffering from the toxæmia that is produced by an intestinal obstruction. That the seriousness of the situation cannot be minimized is seen in the careful review of 400 cases of acute intussusception made by Perrin and Lindsay. In cases of acute irreducible intussusception under all forms of treatment, they report a mortality of 100 per cent in children under 2 years of age and 70 per cent in older children. The surgeon who finds that his patient has an intussusception that he cannot reduce faces a grave problem. He may try various procedures such as: (1) an artificial anus by making an enterostomy or a colostomy above the obstruction, leaving the intussusception in the abdomen; (2) a lateral anastomosis around the obstruction leaving the intussusception in the abdomen; (3) a resection of the intussusception making an artificial anus of the ends of the bowel as in the Mikulicz's operation; (4) a resection of the intussusception with a lateral or end-to-end anastomosis; (5) a resection of the intussusception through an incision in the outer layer as in the Coffey operation.

Certain objections have been raised against each of the various operations. In these very young children, any operation which includes the making of an artificial anus will probably lead to a fatality as the infant loses too much food and water through the artificial opening. Other writers have objected to those operations which leave the intussusception in place as they think there is a grave danger in the sloughing that will follow. The ideal treatment, of course, is to remove the strangulated portion and re-establish the continuity of the bowel by anastomosis. Unfortunately,

[1]Read before the Chicago Surgical Society, January 4, 1930.

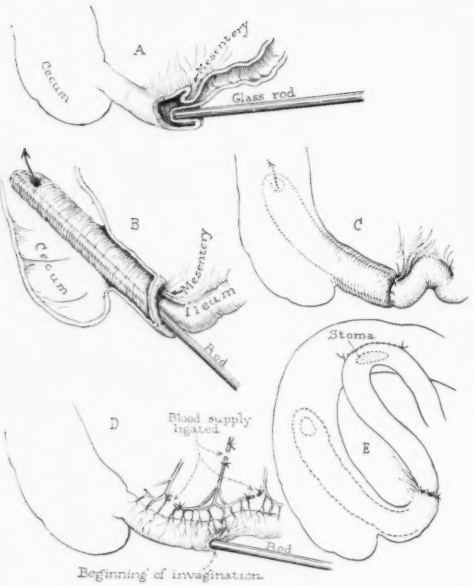


Fig. 1. A, Intussusception produced in the lower ileum by invagination with a glass rod. B, The intussusception pushed through the ileocæcal valve into the ascending colon. C, The neck of the intussusception fixed by interrupted silk sutures. D, Portion of the lower ileum deprived of its blood supply by ligation before invagination. E, Lateral anastomosis between ileum and ascending colon to short circuit around the intussusception.

however, all such operations seem to be too formidable for young children. Although Kocher reported a successful outcome in 5 such cases,

Fig. 2. Condition of invaginated bowel after sloughing subsequent to blood supply ligation.

other writers, for instance Perrin and Lindsay, had a mortality of about 100 per cent. The Coffey operation, in which a longitudinal incision is made in the outer layer and through this opening the intussusception is excised and its neck sutured, is performed in a highly infected field. It has not proved to be successful in our hands.

The method used occasionally by nature to cure some of these cases of irreducible intussusception is like the Coffey operation in principle. Treves in describing the condition says: "If the intussusception be irreducible then cure by spontaneous reduction is impossible as is also reduction by means of forcible enemata or by laparotomy. On the other hand if the tissues of the mass be glued together by adhesions about the neck, the parts are most advantageously placed for spontaneous recovery by elimination of the gangrenous intussusception." Thompson, in reporting a case of spontaneous cure by elimination, says that this

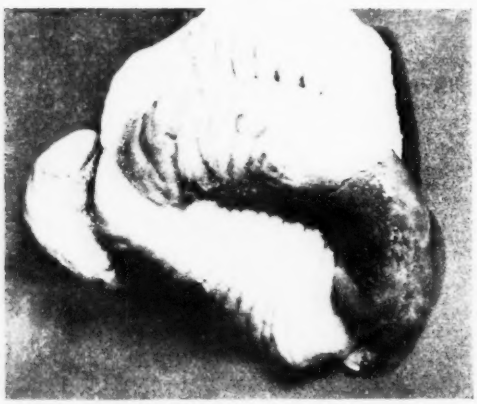


Fig. 3. Condition of bowel 5 days after ligating blood supply to invaginated bowel.

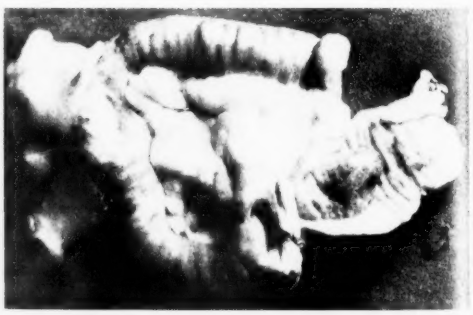


Fig. 4. Showing stump of invaginated bowel after sloughing and anastomosis.

TABLE I.—RESULTS AFTER INVAGINATION OF 6 TO 10 INCHES OF ILEUM INTO AND THROUGH THE ILEOCÆCAL VALVE AND FIXATION IN POSITION BY INTERRUPTED SUTURES THROUGH THE SEROSA

Dog No.	Symptoms					No. of days alive	Postmortem findings
	V.	B. S.	L. W.	D.	Dist.		
1	−	−	−	−	−	43	Invagination spontaneously reduced and bowel normal
2	−	−	−	−	−	48	Invagination intact with œdema of invaginated bowel but patent
3	−	−	−	−	−	53	Invagination intact with œdema of invaginated bowel but patent
4	−	−	+	+	+	57	Bowel somewhat distended with signs of a mild obstruction
5	−	−	−	−	−	61	Invagination intact with a normal bowel
6	−	−	+	+	+	48	Signs of mild obstruction due to œdema of invaginated bowel
7	−	−	−	−	−	2	Dog died of infection and evisceration
8	−	−	−	−	−	42	Invagination intact with a normal bowel
9	−	−	+	+	−	35	Œdema of invaginated bowel but still patent and functioning
10	−	−	+	+	−	35	Œdema of invaginated bowel but still patent and functioning
11	−	−	−	−	−	31	Invagination intact—bowel normal
12	−	−	−	−	−	24	Invagination intact—bowel normal
13	+	−	+	−	+	25	Invagination intact with a piece of bone lodged in bowel producing a partial obstruction

V.—Vomiting. B. S.—Bloody stool. L. W.—Loss of weight. D.—Diarrhœa. Dist.—Distention.
Average number of days that dogs lived is 42. These dogs were all killed.

must have been a relatively frequent termination of intussusception in the period when these patients were all treated by non-surgical methods. He quotes from Leichtenstern's book published in 1879, in which it is stated that spontaneous elimination occurred in 42 per cent of 513 cases. Since the advent of surgery in the treatment of intussusception, reports of spontaneous elimination have naturally been somewhat rare. Fitzwilliams, in 1908, does not mention a single case in a series of 1,000 and Perrin and Lindsay, in 1921, said it did not occur in their series of 400 cases. Single cases have been reported by O'Connor, Sherrin, and Sutcliffe.

It was only by taking advantage of this tendency to spontaneous cure that we were able to achieve

TABLE II.—RESULTS OF INVAGINATION OF 8 TO 10 INCHES OF BOWEL, WHOSE BLOOD SUPPLY WAS SHUT OFF BY LIGATION AND RESECTION OF VESSELS, INTO AND THROUGH THE ILEOCÆCAL VALVE AND FIXATION IN POSITION BY INTERRUPTED SUTURES THROUGH THE SEROSA

Dog No.	Symptoms					No. of days alive	Postmortem findings
	V.	B. S.	L. W.	D.	Dist.		
1	+	−	+	+	+	35	Bowel distended for 5 feet with signs of sloughing of invaginated bowel
2	−	−	−	−	−	34	Strangulated bowel sloughed off with stricture of the stump but patent
3	+	+	+	+	+	37	Bowel enormously distended with sloughing and stricture of stump
4						1	Dog died of hæmorrhage into bowel
5	+	+	+	+	+	48	Enormously distended bowel with sloughing and stricture of stump
6	+	+	+	+	+	36	Typical sloughing of bowel with stricture of stump but patent
7	+	+	−	−	−	2	Dog died of hæmorrhage into bowel
8	+	+	−	+	+	5	Free blood in bowel with gangrene of strangulated portion
9	+	+	+	+	+	22	Typical sloughing with cicatricial contraction of the stump
10	+	+	+	+	+	41	Enormously distended bowel with the typical sloughing and stricture
11	+	+	−	+	+	5	Free blood in bowel with picture of acute obstruction
12	+	+	+	+	+	30	Typical picture of chronic obstruction with sloughing and stricture of stump
13	+	+	+	+	+	58	Typical picture of chronic obstruction with sloughing and stricture of stump
14	+	+	+	+	+	57	Typical picture of chronic obstruction with sloughing and stricture of stump

Average number of days that dogs lived is 34. This excludes the 2 dogs that evidently died from hæmorrhage into the bowel.

success in 2 cases after total failure in other cases in which the procedures involving resection already mentioned were used. Our good results were attained by simply fixing the intussusception in place by a row of interrupted silk sutures about the neck and then making a lateral anastomosis between the ileum and the colon distal to the intussusception. Our first patient was a girl, 7 months of age. From the history given by the mother and the objective findings, we felt that the

TABLE III.—RESULTS OF INVAGINATION OF 8 TO 10 INCHES OF BOWEL—WHOSE BLOOD SUPPLY HAS BEEN SHUT OFF BY LIGATION AND RESECTION OF THE VESSELS—INTO AND THROUGH ILEOCÆCAL VALVE, AND ANASTOMOSIS OF THE LOWER PORTION OF THE ILEUM TO THE CÆCUM. DOGS WERE KILLED ON THE AVERAGE OF 60 DAYS AFTER OPERATION

Dog No.	Symptoms	Postmortem findings
1	None	Bowel normal with sloughing of strangulated portion and healing
2	None	Bowel normal with sloughing of strangulated portion and healing
3	None	Bowel normal with sloughing of strangulated portion and healing
4	None	Bowel normal with sloughing of strangulated portion and healing
5	None	Slight distention of bowel but otherwise same as above
6	—	Dog died on the sixth day due to evisceration
7	None	Bowel normal with typical sloughing and healing. Stump not patent
8	None	Bowel normal with typical sloughing and healing. Stump not patent
9	None	Bowel normal with typical sloughing and healing. Stump not patent
10	None	Bowel normal with typical sloughing and healing. Stump not patent
11	None	Bowel normal with typical sloughing and healing. Stump not patent

These dogs gained weight and in general were in much better condition than at time of operation.

child had an intussusception of 5 days' standing. At operation an irreducible intussusception was found at the ileocæcal valve. The child's general condition was so poor at the time of operation that we felt that a resection would be fatal. We decided to leave the mass in place and fixed it by a row of interrupted stitches. Then a lateral anastomosis was made between the ileum and the colon. The patient made an uneventful recovery and left the hospital in 12 days. At no time could we find any evidences of sloughing tissue in the stools.

Our second patient was a little Italian boy, 8 months of age. According to his history the child had been sick for 2 days with an intussusception. When brought to the hospital, he was apathetic and apparently in poor condition. At operation an intussusception about 10 inches long was found. It consisted of the ileum that had invaginated itself into the cæcum. Part of the intussusception could be milked out but about 6 inches remained firmly fixed by a local adhesive peritonitis. The invaginated bowel was grayish black and began to show signs of tearing when more force was applied in an attempt to free it. As it was evidently irreducible, the mass was left in place and fixed by a row of interrupted silk sutures around the neck. A lateral anastomosis was made between the lower ileum and the ascending colon. The child had a somewhat stormy convalescence because of an attack of bronchopneumonia. He left the hospital, however, at the end of a month in good condition. Daily examination of the stools failed to show any gross pieces of sloughed tissue.

Encouraged by the successful outcome in these two cases, but realizing that our experience was too small to permit us to draw any definite conclusions, we thought it would be worth while to try out this method of treating intussusceptions produced experimentally in dogs. With that object the following group of experiments was performed:

The operation, under ether anæsthesia, consisted of a right rectus incision followed by the delivery of the lower end of the ileum and the cæcum into the wound. The lower 8 to 10 inches of the ileum was then invaginated into and through the ileocæcal valve by means of a glass rod which was pointed at one end and blunt at the other (Fig. 1 A, B, and C). This portion of the bowel was chosen because of the frequency of intussusception at this point. No difficulty was experienced in invaginating the bowel provided a sufficient time was allowed to elapse to permit the ileum to relax following an initial spasm. Care had to be exercised not to strip the mesentery from the invaginating bowel. The bowel was fixed in position by means of interrupted silk sutures. However, after a series of 10 dogs it was discovered that the bowel disinvaginated itself by sliding out along the fat mesentery. Therefore it was found that a suture through the mesenteric attachment was necessary to hold the bowel in position.

The first group of dogs in general remained symptomless and in good condition despite the invagination. The invaginated bowel remained patent and there was, in most cases, very little pathological change present at postmortem (Table 1). Frequently the only pathology present was a slight œdema of the invaginated portion which apparently did not interfere with function of the bowel. This demonstrated in dogs that merely invaginating the bowel was not sufficient to produce interference to the blood supply with the resulting picture of intussusception as seen in man.

In the second group of dogs in addition to invaginating the bowel, the blood supply to that portion was first shut off by ligating and resecting

all the vessels supplying that section (Fig. 1 D). These dogs had an uneventful recovery from the operation but in contrast to group 1, almost immediately began to lose weight, gradually become distended followed by vomiting, diarrhœa, bloody stools, and death (Table II). The postmortem revealed an emaciated dog with a very marked distended bowel, especially the lower end of the ileum (Fig. 2). The strangulated portion of the ileum had sloughed off leaving a stump with a constricted lumen which was usually pulled to one side by the cicatricial contractions. It is interesting to note that all these dogs, with three exceptions, died of chronic obstruction to the bowel. The three exceptions were dogs, numbers 8 and 11, which died, showing a typical picture of acute obstruction (Fig. 3) at the end of 5 days, and dog number 2, which was killed at the end of 34 days without any signs or symptoms of obstruction. The dogs lived on an average of 34 days.

In the third group, after shutting off the blood supply and invaginating as before, an anastomosis of the lower end of the ileum and cæcum was done (Fig. 1 E). These dogs in contrast to group II, almost immediately began to gain weight, were very active, and at no time showed any signs of obstruction. When killed at the end of 60 days on the average, they were fat, active, and in general in much better condition than at time of operation (Table III). Postmortem examination revealed a normal bowel with the strangulated portion sloughed off leaving a stump whose lumen, in most cases, was closed by cicatricial contractions (Fig. 4).

SUMMARY AND CONCLUSIONS

Two young children with very definite irreducible intussusceptions were successfully treated by fixing the irreducible part in position by a row of silk sutures placed about the neck and short circuiting this obstructed portion by a local anastomosis.

The rationale of this method of treating irreducible intussusceptions would seem to be supported by the results of experimental work done on dogs.

1. In dogs, in which a portion of bowel is invaginated and fixed, there is first a very strong tendency toward spontaneous reduction and in case the invagination remains in place, the bowel will function with little disturbance in the general health of the dog.

2. Invagination alone is not sufficient in dogs to produce an obstruction to the blood supply to the invaginated portion of the bowel.

3. Dogs in which the blood supply to a portion of the bowel is first shut off and then invaginated will die with a picture of chronic obstruction.

4. Lateral anastomosis of ileum to cæcum around the intussuscepted portion of bowel will permit a normal function of the remainder of the bowel with no disturbance to the general health of the dog.

BIBLIOGRAPHY

1. Coffey, R. C. Ann. Surg., 1907, xlv, 42.
2. Fitzwilliams, D. C. Lancet, 1908, i, 628.
3. Kocher. Brit. M. J., 1898, October.
4. Leichtenstern, O. Ziemssen's Cyclopedia of the Practice of Medicine, 1877, vii, 612.
5. O'Connor, E. M. H. Brit. M. J., 1894, ii, 123.
6. Perrin, W. S., and Lindsay, S. C. Brit. J. Surg., 1921, ix, 46.
7. Sherrin, J. Clin. J., 1906, xxvii, 185.
8. Sutcliffe, A. Brit. M. J., 1894, ii, 123.
9. Thompson, Lawrence H. Am. J. Dis. Chil., 1927, xxxiv, 640.
10. Treves, Sir Frederick. Intestinal Obstruction. New York: William Wood and Company, 1899.

CORRESPONDENCE

MARCUS WHITMAN—A CORRECTION

In the June number of SURGERY, GYNECOLOGY AND OBSTETRICS, the Editors published a portrait which bore the name of Dr. Marcus Whitman. Stephen B. L. Penrose, president of Whitman College, who is the author of the biographical sketch of Dr. Whitman, immediately objected to its publication.

It appears that there never has been an authentic portrait of Dr. Whitman. The one in question is based upon an alleged resemblance between Dr. Whitman and a clergyman who lived in Chicago. This same picture was published in the first edition of Dr. O. W. Nixon's book, *How Marcus Whitman Saved Oregon*. Its publication was followed by a storm of protest from those who knew that it was not genuine. At the time, Dr. Penrose was criticized severely for its appearance in Dr. Nixon's book. Consequently, he now feels that the publication of the photograph in connection with an article written by himself is a reflection upon his honor.

The Editors wish to state that this photograph was published in spite of Dr. Penrose's insistence that there were no authentic portraits of Dr. Whitman. In their zeal to present a likeness of the subject of Dr. Penrose's sketch, they failed to place sufficient reliance upon the author's statement. They wish, therefore, to assume the responsibility for this error and to express their regrets to Dr. Penrose for the occurrence of this unfortunate incident.

EDITORIALS

SURGERY, GYNECOLOGY AND OBSTETRICS

FRANKLIN H. MARTIN, M.D.....Managing Editor
ALLEN B. KANAVEL, M.D.....Associate Editor
LOYAL DAVIS, M.D.....Assistant Editor

WILLIAM J. MAYO, M.D.....Chief of Editorial Staff

SEPTEMBER, 1930

HUNGARIAN SURGERY

THE average American surgeon visiting the clinics of Europe feels, that when he has spent some time in Vienna, it is time to retrace his steps westward and begin his preparation to sail for home, little realizing that a five hour journey will take him to Budapest, that ancient city of charm and tradition, where the surgeons are of the highest type, the clinics most modern and progressive and that a visit filled with great value and indescribable charm awaits him if he would but continue his surgical pilgrimage a little farther eastward.

The present population of Hungary is 8,000,000. There are 1,200,000 inhabitants in the city of Budapest. The University of Budapest, founded in 1560 by Pazmany Peter, is independent of city and state control. It has had autonomy since the days of Maria Theresa in 1710. There are at present 4,500 students in the University, 1,600 of whom are in the medical school. The medical course for a degree of Doctor of Medicine is six years, two extra years are spent in a hospital and clinic for those who want to follow a specialty. It is impossible to practice surgery or any specialty in Hungary without this additional work for which a special diploma is given.

There are two surgical clinics in the University of Budapest with 180 beds each, under Professor Verebely and Professor Bakay, each clinic performing about 3,500 operations yearly. There is also a clinic of 120 beds in urology under Professor Illyés, performing approximately 1,000 operations yearly; two clinics in gynecology and obstetrics with 140 beds each; three clinics in medicine with 120 to 140 beds each; a clinic for children with 300 beds; clinics in otolaryngology, ophthalmology, and dermatology with 100 to 140 beds and a clinic in neurology with 300 beds. There are, therefore, 2,000 beds for teaching clinical medicine and surgery in the University and there are various institutes of anatomy, physiology, pathology, and hygiene. Besides there are six large city hospitals independent of the University and under city government, namely: St. Rokus' with 1,400 beds, St. Johan's with 1,200 beds, St. Stephan's with 1,400 beds, St. Gellert's with 3,000 beds, St. Margaret's with 400 beds; and old St. Johan's with 300 beds. The total bed capacity in the city hospitals is 7,700. These six city hospitals have nine surgical divisions under outstanding surgeons—Professors Hueltl, Manninger, Winternitz, Pólya, and Adam. These men serve as clinical professors of surgery of the faculty of the University and teach the students clinical and operative surgery. The visiting surgeon should see all of these men work, as well as the two Pro-

fessors, Verebely and Bakay, in the University.

There are several private sanatoria in the city, notably the Pajor and the Fasor, where the private patients go for operations and treatment. These sanatoria are modern in every way and beautifully equipped.

The Rockefeller Foundation has done a fine work for Hungary in that it has given $3,500,000 to help establish a Department of Public Health under the direction of Professor Johan, an able bacteriologist and pathologist. To this institute, all the health directors are called, at regular intervals, for instruction in sanitation, bacteriology, and hygiene. The Foundation is about to build and endow a much needed school for nursing, as it has recently done in Poland.

One is impressed with the number of operations for malignancy of the stomach and large intestine in the clinics of Budapest, the frequency of ulcer of the duodenum and stomach, gall stones, and hydatid cyst. These operations are done with swiftness, dispatch, and gentleness, which bespeaks a full knowledge of anatomy, pathology, and a mastery of technique. Nearly all of the major operations are performed under a general anæsthetic, but the operations which are done under forms of local anæsthesia are well done and one does not observe the patient suffering during their performance as he is wont to do in some of the European clinics. Here is to be seen the Hueltl stomach machine used for aseptic resections of the stomach and large intestine, a most ingenious instrument, which greatly reduces the time and the danger of these resections and is the product of the mind of that brilliant and outstanding surgeon, Professor Huemér Hueltl.

The Hungarian surgeon is an enthusiastic teacher. He is a master technician with a most accurate and practical knowledge of anatomy. He is a man of gentle touch and kindly feeling for the unfortunate patient. There is a fine patriotic spirit among all Magyars who have a strong fellow feeling for each other. Nowhere in my travels abroad have I seen such consideration and feeling for the comfort of the poor patient nor greater gentleness shown the unconscious man's tissues.

After three trips to Budapest since the war, I am impressed with the surgery, the hospitals, and the master surgeons. A visit to this old world city is a delight filled with interest. The people are charming and most cordial, the food is delicious, the gypsy music indescribable, and the whole atmosphere of the city is one that makes the visit long to be remembered. DONALD GUTHRIE, M.D.

INTRAVENOUS UROGRAPHY

THEORETICALLY it would hardly seem possible that any substance injected intravenously could be secreted by the kidney in such a concentrated form as to cast a shadow of the renal pelvis and ureter in the roentgenogram. However, in 1923, Rowntree, Osborne, Sutherland and Scholl, in The Mayo Clinic, were the first to show that the renal pelvis and the bladder could be outlined following intravenous injection of large doses of sodium iodide, and they deserve full credit for demonstrating the practicability of intravenous urography. Not alone did they demonstrate the feasibility of outlining the upper part of the urinary tract by this method, but they also indicated the possibility of similarly rendering other organs visible in the roentgenogram, specifically referring to the liver, vascular system, and spleen. Their suggestions were soon followed by the demonstration of cholecystography by Graham.

Unfortunately, the technique proposed for intravenous urography did not permit of general use, chiefly because of the necessity of establishing tolerance to the massive doses of sodium iodide necessary to cast a shadow, and because the shadow of the pelvis and ureter was frequently too indefinite for interpretation. Although the method suggested by Rowntree and his associates was not generally employed, nevertheless it is remarkable how clearly the renal pelvis and the bladder frequently can be outlined in patients who have become tolerant to iodine, after the intravenous injection of 200 cubic centimeters or more of a 15 per cent solution of sodium iodide. The discovery that intravenous urography was feasible stimulated various observers to find a solution more amenable for this purpose and the problem became one of chemistry.

It was evident that the greatest objection to solutions of sodium iodide employed was the fact that the iodine in its free form was poorly tolerated and did not permit greater concentration in the urine. It was necessary to find a combined form of iodine which would have none of the toxic qualities of the free iodine and would be secreted in a higher concentration. Roseno described a substance which combined iodine with urea and which was secreted in sufficient quantity clearly to outline the renal pelvis in many cases. Soon afterward, he reported his experience in a number of patients with various lesions, in which he thoroughly evaluated the method and placed it on a clinical basis. Unfortunately, however, the substance was toxic to certain patients and consequently did not meet with general acceptance.

A combination of iodine in high concentration with a pyridine ring had been discovered previously by Binz and Raeth of Berlin; this was called "selectan neutral," and was being employed intravenously as an antiseptic. Among the first to work with this solution was Hryntschak, who as early as 1927 employed it to outline the urinary tract in animals, but was unable clearly to demonstrate its feasibility for general use. Swick, a fellow on the Libman Foundation, working with Lichtwitz at Altona, recognized early in 1929 the value of the selectan group in outlining the urinary tract following intravenous injection. However, it proved to be toxic in some cases and the shadow of the renal pelvis was frequently uncertain. Working with von Lichtenberg and Swick, Binz made various modifications which obviated the objectionable features, leaving a substance which on intravenous injection was not toxic and which outlined the pelvis and ureter sufficiently to permit interpretation of any existing abnormality. This substance was called "uroselectan." With characteristic Teutonic thoroughness von Lichtenberg insisted on an exhaustive trial by a group of representative American urologists before uroselectan should be distributed for general use; their results were submitted at a recent meeting of the American Urological Association.

Uroselectan is now available for use by the medical profession and undoubtedly will prove to be a valuable adjunct to general diagnosis. Judging from the experience of those who have employed it, its greatest value probably will be in determining the condition of the kidneys in cases in which ureteral catheterization is difficult or impossible. This would include intolerant patients; patients with contracted tuberculous bladder, anatomical obstruction of the ureter, extensive vesical neoplasm, prostatic obstruction, impassable stricture of the urethra; patients who have undergone rectal implantation of the ureters; infants and patients in whom introduction of the cystoscope is difficult because of deformities. The intravenous method permits bilateral pyelography without any of the dangers accompanying bi-

lateral retrograde pyelography; this should be of particular value in the presence of polycystic kidney, bilateral hydronephrosis, and fused and solitary kidney. It will also be a valuable adjunct to the list of tests of differential renal function, which frequently have left doubt as to the functional capacity of the kidney under investigation. Incidentally, uroselectan offers a much better medium for retrograde pyelograms than sodium iodide in that it has none of the irritating qualities of the latter, and, because of the large content of iodine, it casts a dense shadow.

Although the method of intravenous urography is now available to the general profession, it must be remembered that the interpretation of the urogram is frequently difficult and should be referred to those who have had extensive experience.

It should be emphasized, moreover, that although in some cases the use of uroselectan may render cystoscopic examination unnecessary, nevertheless its interpretation will often have to be accompanied by cystoscopic data in order to complete the diagnosis.

It will be found that the outline of the pelvis and calyces is not always distinct in the urogram obtained by intravenous injection and that minor evidence of abnormality, such as occurs with renal tumor and renal tuberculosis, is easily overlooked. In doubtful cases a retrograde urogram will be necessary.

Thus, by the work of various contributors, intravenous urography has now been placed on a practical basis. That it will prove to be a valuable adjunct to urologic as well as to general abdominal diagnosis and surgery is evident.

WILLIAM F. BRAASCH, M.D.

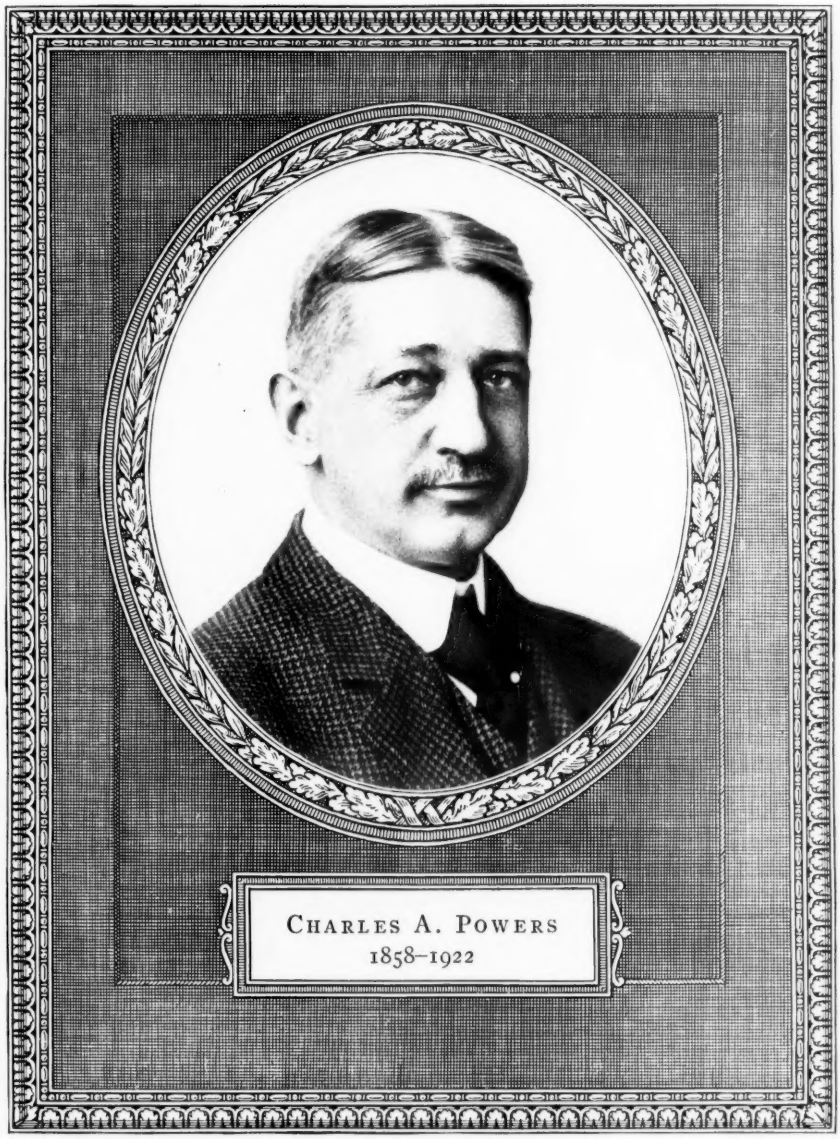
MASTER SURGEONS OF AMERICA

CHARLES ANDREW POWERS

CHARLES ANDREW POWERS, the son of George Eliot and Jennie Stow Powers, was born in Lawrence, Massachusetts, February 2, 1858. He attended the public schools of Massachusetts and began the study of medicine in 1879 under the direction of Dr. A. J. Stevens, of Malden, Massachusetts, who continued to serve as his preceptor during his undergraduate days at the College of Physicians and Surgeons of New York, from which in 1883 he received the degree of M.D.

It is unfortunate that his earlier biographical record can not be adequately written. His pre-medical education, the circumstances that led to his choice of medicine as a profession, as well as to his selection of surgery as a specialty, would unquestionably be of the greatest interest. He, however, rarely, if ever, referred to his earlier years, and in spite of diligent inquiry from many of those of his classmates and intimate friends who still survive, these topics must unfortunately remain unanswered. That an ultimate surgical career was seriously considered by him when still a student is shown by his selection of the subject of "Intestinal Obstruction" for his graduating thesis. This, his first contribution to surgical literature, was unfortunately never published.

His student days in the College of Physicians and Surgeons must be passed over quickly. At that time "Twenty-third Street" was a proprietary institution, and two full courses of lectures in seven subjects, extending over a period of at least two years and at a cost of two hundred and eighty dollars, were the sole qualifications for admission to the final examination. College intimacies and associations were not encouraged, and attendance at the didactic lectures was frequently irregular and at times entirely neglected. Students having university degrees, always in the minority, were ordinarily most industrious and ambitious and the majority of those on the "Honor Roll," or the first ten in each class, graded solely by the result of the final examination, were usually members of this group. On the other hand, those without previous college experience were frequently dazzled by the opportunities for pleasure which the "Great White Way" (in those days it was the "Red Light District") afforded, and their medical education suffered accordingly. Powers, however, although handicapped by the lack of a previous college education, was diligent and painstaking, and while he



CHARLES A. POWERS
1858–1922

was not a member of the magic "Honor Roll," his scholarship and medical knowledge were such that he successfully passed the acid test of a competitive hospital examination and was appointed an interne on the house staff of the "House of Relief" which was the emergency receiving department of the New York Hospital. Here in 1883 and 1884 he served for 16 months, the last four of which as house surgeon, and attracted the favorable attention of Dr. W. T. Bull, the visiting surgeon to the hospital, to whom, after further study abroad in Paris, Heidelberg, and London, he became a personal assistant. This association, of which Powers was justly proud, marked most auspiciously the beginning of his surgical career, for Bull was most popular and capable and inspired both devotion and energy in those who were fortunate enough to attract his friendly interest. Guided by such a mentor, Powers was soon placed in charge of the surgical outpatient department of the New York Hospital, and a year or two later was appointed visiting surgeon to the St. Luke's and Cancer Hospitals. For several years, associated with his classmate J. E. Newcomb, he conducted recitations in anatomy and surgery in an extramural quiz and undoubtedly profited greatly by this experience in teaching. At that time the college curriculum, consisting entirely of didactic lectures, was supplemented by quizzes conducted by groups of recent graduates, which had no official connection whatever with the organization of the medical school. These quizzes were voluntarily patronized by ambitious students who could afford the added expense, for internes were appointed to the more desirable hospitals only after competitive examinations, and as these were always keenly contested, the personal instruction given members of a well organized quiz undoubtedly enhanced their chances of ultimate success.

Only the strongest constitution could have endured the demands of so great a burden of professional work, and it was not at all surprising that Powers' health became impaired. St. Luke's Hospital was at that time a hot bed of tuberculosis, and it is more than possible that his pulmonary infection may have been contracted "in the line of professional duty." As soon as the diagnosis was corroborated he left New York for Saranac and in 1894, after a year in the Adirondacks, he moved to Denver, Colorado.

It is impossible to conceive how keen his disappointment must have been when he was compelled to forego his brilliant prospects in New York. He was undoubtedly on the high road to professional and social success. Many loyal friendships were suddenly interrupted and this sacrifice alone must have proved a cruel hardship. To blows of much less intensity many have succumbed and have aimlessly, and without achievement, lived out their allotted time. Not so with Powers! Improved in health and with the dreaded infection at a standstill, he figuratively "rolled up his sleeves" and in a surprisingly short time became a leader in the surgical profession of the city of his adoption. He was appointed professor of surgery in the medical department of the University of Colorado,

and in 1896 was elected a fellow of the American Surgical Association. In 1901 the honorary degree of M.A. was conferred on him by the University Staff of which he had become a member.

Instead of acting as a depressant, the tubercular virus circulating in his system seemed to act as a stimulant and gave him renewed vigor. It is possible that it even enhanced his professional skill, for instances of this nature are not unknown. Under a similar handicap the distinguished Stevenson was most productive and his works have a literary charm that it is difficult to surpass. In the medical profession the much beloved Trudeau achieved a national and international reputation and the sanatorium for tuberculosis which he founded in Saranac will always serve as a mute memorial to his professional skill.

The career of Powers in Denver was tantamount to that which he would have achieved in New York. In an interesting obituary notice by his colleague, Dr. Freeman of Denver, it is stated that "at various times he was surgeon to most of the hospitals in Denver." He was a member of numerous surgical societies both in this country and abroad. From his membership in the American Surgical Association and the American Society of Clinical Surgery he derived the greatest satisfaction, not only because of the scientific value of their meetings, but chiefly because of the opportunities afforded for close and intimate friendships with fellow members. He served the American Surgical Association as vice-president in 1903, as treasurer from 1906 to 1912, as president in 1912, and from 1906 to 1916 as a member of its council.

Though never the author of a textbook or extensive surgical treatise, Powers was a prolific contributor to surgical literature. From the very beginning he participated actively in the surgical discussions of the state and other local societies, and these discussions were both earnest and convincing. The writer recalls no meeting of the American Surgical Association in which he did not contribute a paper and in the meeting of 1909, two papers (a most unusual occurrence) were read by him.

In his surgical work, Powers could not be called a brilliant or daring operator. In this field he never cultivated the "dramatic" quality. On the contrary, he was careful, conscientious, and painstaking in his surgical technique, rather than speedy in mechanical execution. In consultation, skill in diagnosis was probably his greatest asset, to which his wide experience and reading, his keen power of observation, and a naturally analytical mind largely contributed.

He was justly proud of his military services in France and to his own country during the world war. Whether or not he contemplated military service in the Spanish-American war of 1898 is not known. It is probable that he was deterred from taking part in this conflict by his comparatively recent tuberculous infection. In 1908, however, the first year of its organization, he was appointed a lieutenant in the U. S. Medical Reserve Corps. Shortly after the outbreak of the

world war, keenly sympathetic with France, he retired from civil practice and became an attending surgeon to the American Ambulance Hospital in Paris. With few interruptions he remained abroad until the close of the war. In July, 1917, he was appointed major in the medical corps of the U. S. Army and assigned to duty in the American Hospital, No. 1, at Neuilly, receiving his discharge in December, 1918. On returning home he became a lieutenant-colonel in the U. S. Reserve Corps. In recognition of his services abroad he was awarded the Medaille de la Reconnaisance Française, elected a Chevalier of the Legion of Honor, and an officer of the order of Leopold II of Belgium. Congress awarded to him the distinguished service medal which, arriving too late to be presented to him before his death, was pinned, at his funeral in Denver, upon the uniform in which he was buried. His body was interred in Arlington Cemetery.

At the close of the war, Powers did not, like many others, resume surgical practice. While he could have afforded to have rested on his well earned laurels, his energy and his desire to be of public service did not abate. Perhaps the tubercular virus was still active. He soon took the greatest interest in the Society for the Control of Cancer to which he was chosen president and to the affairs of which he gave his undivided attention. The wide publicity campaign against this terrible scourge was largely directed by him, and, although the end is unfortunately not yet in sight, he contributed most effectively to the growth of this most important activity.

In this brief résumé of the career of Dr. Powers, little has been said of his domestic life and personal traits. His marriage, contracted relatively late in life did not prove fortunate and had only a brief existence. To his friends he was both loyal and helpful. His standards were naturally high and unprofessional conduct of all kinds excited his displeasure. This in itself provoked certain animosities. No one of strong character is without enemies and these were treated always with a certain ironical sarcasm which bordered on contempt. Perhaps a reliable measure of character is the number and strength of the friendships an individual enjoys. Of equal, if not of greater value, is the attitude of the younger generation toward their chief. In the former Powers was particularly fortunate, and in the latter, the sincere admiration and at times even of affection in which he was held by his juniors was a personal tribute that must have afforded him the greatest satisfaction. Like Gulliver in the *Liliputians*, he was well fortified against the pricks of adverse or hostile criticism.

In addition to membership in the important social clubs of Denver, Powers was a member of the Century Association in New York. This was a favorite "sanctuary" to him in his frequent visits east, and he enjoyed intimate contact with many of its members. At the annual meeting shortly following his death a touching tribute was paid him by the secretary of the association, Mr. Alfred Dana Noyes.

On December 23, 1922, Dr. Powers died suddenly in Denver of cerebral apoplexy. His death occurred without premonition or any previous disturbance of his mental faculties. He had shown no lack of interest in his various activities nor had any diminution in the energy with which he approached different problems been observed. When he was stricken he was in the midst of dispatching Christmas cards to friends at home and abroad. How much to be envied is such an end to a busy and fruitful career! How vastly preferable to the lingering illness and gradually increasing incapacity so often observed in the final illness of those advanced in years! And, then too, what more perfect message could one wish to bequeath his fellow men than the expressions of peace and good will to all which his Christmas cards conveyed. The continued esteem and affection of one's surviving friends is a much to be envied tribute to which all may aspire but which few attain. Powers, or "Charlie" Powers as he was affectionately known to many friends, undoubtedly had the rare distinction of so living in the hearts of those who enjoyed the privilege of his friendship. ELLSWORTH ELIOT, JR.

DE
RATIONE CVRANDI
PER SANGVINIS MISSIONEM,
Libri Decem.

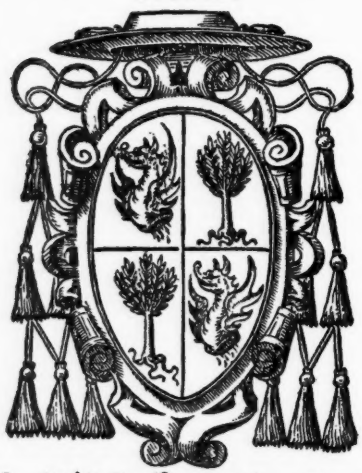
In quibus extirpatis erroneis opinionibus paſſim hodie apud nonnullos vigentibus, omnia ad hoc argumentum pertinentia, ſecundum Galeni doctrinam explanantur.

AVTHORE

HORATIO AVGENIO MEDICO, ET PHILOSOPHO
hac noſtra ætate præſtantiſſimo.

Addidimus eiuſdem diſputationem aduerſus A. Mercenarium ordinariam Philoſophiam in Patauino Gymnaſio profitentem.

ILLVSTRISS. ET REVERENDISS. D.
VINCENTIO LAVREO S. R. E.
CARDINALI AMPLISS.
DICATI.



TAVRINI, Apud Io. Baptiſtam Ratterium. M D LXXXIIII.

Cum licentia Superiorum.

THE SURGEON'S LIBRARY

OLD MASTERPIECES IN SURGERY

ALFRED BROWN, M.D., F.A.C.S., OMAHA, NEBRASKA

THE BLEEDING MANUAL OF AUGENIUS

IN order to understand clearly the importance of this little book which went through three editions between 1575 and 1597, it is necessary to review the changes in medical doctrine and thought leading up to the great argument concerning bleeding which was taking place during the sixteenth century. From the earliest times the idea that disease was caused by some changes in the blood was almost universal. Hippocrates believed this to be a "pneuma" or air which was present in the blood and a change in it gave rise to disease. Consequently, in order to relieve the body of this poison, the drawing of a certain amount of blood at a definite time was indicated in various diseases. Hippocrates believed that venesection should be done according to the theory which he called revulsion. That is, that the blood should be withdrawn from the same side of the body which was diseased and should be withdrawn in fairly large quantities. In this he worked upon the idea that withdrawal of the blood from the abnormal part allowed new blood to come in and help to cure the disease. The ideas of Hippocrates were, many of them, controverted by Galen, and his followers—the Arabian physicians. Galen and the Arabians consequently introduced a new theory. This they called derivation and the technique consisted in drawing blood from a part of the body distant from the site of the lesion, usually the other side of the body, and withdrawing it very slowly, drop by drop; the idea being, that in this way the blood was brought away from the part involved and the part was deprived of its injurious blood. They believed that the theory of Hippocrates was wrong, for they thought that the abstraction of blood near the diseased part in large quantities only brought new blood to the parts and so increased the lesion by the introduction of new blood which was already poisoned.

The employment of the Galenic and Arabian method was almost universal until the early part of the sixteenth century. At this time Brissot, a physician of Paris, who had studied the works of the ancient Greek physicians and had been quietly practising the Hippocratic method of bleeding, came out in 1515 with the open statement that the Hippocratic method was the best one to follow. He had tried it in several cases of pleurisy during an epidemic and found that it was much more valuable than the Arabian method. Immediately his opponents were up in arms and a medical war was started which waged for nearly a century with unabated activity and with lesser activity continued well into the nineteenth century. It seems to us a rather minor matter to have caused so much trouble, but to give an idea of the seriousness of the problem and the bitterness of the quarrel at that time it is only necessary to remember that after Brissot had won over to his side members of the faculty of Paris his opponents obtained a parliamentary decree which stated that his method should not be used, and Brissot had to leave his country and go to Portugal.

Horatius Augenius took sides in the controversy and joined the opponents of Brissot who believed in the doctrines of Galen and the Arabian physicians. He was born in 1527 in the town of Monte Santo in northern Italy. He was the son of a physician, Ludovicus Augenius, who was one of the physicians to the Pope. After an excellent education he decided to go into teaching work. At first, being educated in other things than medicine, he taught logic at the University of Macerata. Then he became professor of theoretical medicine at Rome. He left there a few years later and went to several other towns, still teaching. In 1577 he changed from the theoretical to the practical side of medicine and succeeded Francesco Valleriola as professor of practical medicine at the University of Turin. Finally as the crowning event in his teaching life he was called by the Republic of Venice to the University of Padua, and there remained until his death in 1603 at the age of 76 years.

In his dedication to Cardinal Vincentius Laureus, Augenius lays down what he expects to do in his book. He reviews briefly the prevailing quarrel in the medical profession regarding the letting of blood and places himself squarely on the side of the Galenic doctrine. He states that many are advancing opinions which are not only erroneous but also of great danger to the human race. He says that these men are not really mistaken but err only in that they do not understand the ideas of Galen, and he states that if Galen were alive at this time, or if they had lived at the time of Galen, they would thoroughly understand the subject and there would be no argument. He then goes on to say that he intends to clear up the points under discussion and make the entire medical profession understand the error of the ways of part of it and get together and avoid argument by accepting his views which are correct. This he endeavors to do in the first eight books of his work.

REVIEWS OF NEW BOOKS

THE seventh and eighth revised editions of Professor Schilling's book[1] is an edited translation by a man who states in the preface that he made a pilgrimage to Professor Schilling's laboratory. It therefore probably represents a clear statement of the ideas of the author. The translation appears to be well done and the typography is excellent.

The book is divided into four parts. Part I deals with technique which is an essential introduction to the remaining portions. Part II is an exposition of the theory, morphology and division of the blood picture. In Part III are stated the fundamental principles for clinical use of the blood picture. Part IV is composed of selected examples of practical use of hæmograms. Some of the technical procedures are new and have strange names, e. g. "The Gutta-diaphot" and will have to be tried out by American clinicians and laboratory workers before they are accepted with the same enthusiasm as that shown by the translator. The most significant part of the book has to do with the "blood picture," which must be explained in order to give any clear conception of the substance of the book and its value. "The normal blood picture is made up of circulating, generally matured (although not of the same age), highly differentiated cells, mixed in rather constant proportions. . . Cell consumption (physiologic degeneration) occurs peripherally in the circulating blood; i.e., by destruction in the spleen or through emigration into and consumption in the tissues, together with reduction of their number. The products of cell consumption stimulate blood regeneration. Cell substitution (physiological regeneration) comes from the centers; the count is increased without normally changing the blood picture. A pathological change in the blood picture takes place if these two functions are increased and their limits displaced and interfered with. As long as regeneration, which according to biological laws compensates for every loss, is equivalent to degeneration, sufficient or even increased substitute material is furnished by the accelerated and increased formation and sending forth of normal cells, or their juvenile forms respectively (hypertrophy); it is only after overstimulation and impending exhaustion that the normal primary blood cells reduce into less developed or even dedifferentiated earlier stages (hyperplasia)." On the basis of this theory of the "blood picture" Schilling has devised a "hæmogram" which he asserts to be of very great diagnostic and prognostic value. In Part IV the author cites a great number of cases illustrating the use of the hæmogram in diagnosis and prognosis. The book will doubtless prove useful to the skilled laboratory worker.

[1] THE BLOOD PICTURE AND ITS CLINICAL SIGNIFICANCE (INCLUDING TROPICAL DISEASES). A Guidebook on the Microscopy of the Blood. By Professor Dr. Victor Schilling. Translated and edited by R. B. H. Gradwohl, M.D. 7th and 8th rev. ed. St. Louis: The C. V. Mosby Co., 1929.

J. P. SIMONDS.

A SECOND monographic treatise on the adrenal glands by Goldzieher,[2] is more complete than his first book since it includes most of the modern literature on the subject as well as a consideration of the normal and pathological morphology and function of the adrenals and an interpretation of their disturbances as related to clinical medicine. It is a complete and comprehensive review of the subject. One hundred and twenty-four pages are devoted to the anatomy and physiology of the adrenals and eighty-two pages to pathological anatomy. The remainder of the book is devoted to clinical syndromes and interrelationships and organotherapy. A very useful classified and extended bibliography covers almost one hundred pages. The author attempts considerable worth while analysis, but occasionally expresses opinions unnecessarily based on faith rather than facts. He is well acquainted with the controversial nature of many points relative to the physiology of the adrenals and protects his views by the statement: "It is obvious that a much more exact knowledge is necessary to make the neuro-chemical mechanism of endocrine regulations clearly intelligible." Considered as a whole, the book is briefly inclusive, analytical, but quite hypothetical. The reader is pleased to note, however, that the author does not press insecure claims and frequently writes to the effect that "additional evidence is necessary to make these complicated matters more clear, and there is a wide and fruitful field for future clinical or experimental investigations." The book is well outlined, the subject matter is clearly expressed and can be read with interest and profit by any physician or student interested in the subject. It is a contribution to the subject since it is a systematic discussion of the investigations on the physiology and pathology of the adrenals.

A. C. IVY.

IT seems to be a custom among book reviewers to pick out the defects and errors for the purpose of placing a great deal of emphasis on them. A *Textbook of the Practice of Medicine*[3] by various authors, edited by Frederick W. Price, published by the Oxford University Press, contains 1758 pages and naturally I have not read it through. I have read, however, a number of the major contributions in a critical spirit. Having failed to find anything which, in my opinion, could be improved by change I began to search for omissions.

Subjects which one would expect to find only in a very extensive reference work are covered adequately in this textbook. Such subjects as—the recent work on undulant fever, carbon monoxide poisoning,

[2] THE ADRENALS; THEIR PHYSIOLOGY, PATHOLOGY, AND DISEASES. By Max A. Goldzieher, M.D. New York: The MacMillan Company, 1910.

[3] A TEXTBOOK OF THE PRACTICE OF MEDICINE: INCLUDING SECTIONS ON DISEASES OF THE SKIN AND PSYCHOLOGICAL MEDICINE. By various authors. Edited by Frederick W. Price, M.D., F.R.S. (Edin.). 3d ed. New York and London: Oxford University Press, 1929.

poisoning by tetro-ethyl gasoline, lead encephalopathy, lethargic encephalitis and its sequelæ are treated as fully as could be desired.

Twelve hundred sixty-nine pages of the text are devoted to the subject of general medicine, and the most attractive chapters are on fever and immunity, subjects which are seldom discussed in a one volume text. One hundred pages are devoted to diseases of the skin and 387 pages to nervous and mental diseases. The latter section is unusually concise, lucid, and yet comprehensive. I envy the editor and wish that I could place a copy of this text in the hands of every interne and student. In view of the size of the work, the publishers have seen fit to print the text on a paper which is so thin that it is not sufficiently opaque to prevent the print from showing through. This minor defect is more than compensated by the reduction in size and weight of the book. WILLIAM H. HOLMES.

THE pioneer stage in the clinical use of blood plasma measurements is covered in Rowntree and Brown's book on *The Volume of the Blood and Plasma in Health and Disease*.[1] From personal use of the method, I know it to be simple, rapid, and harmless. The book contains a mass of tabulated data of blood volume determinations by the originators of the method. An honest critique of the procedure is given and the technique described. The normal values are made from determinations on 49 normal men and 25 normal women. These figures seem to represent an inadequate basis for general clinical application. The remainder of the volume presents the available data—usually scant—in a variety of pathological conditions.

The monograph is a small one, uniform with the other numbers of the Mayo clinic series, but it is essential to anyone interested in the use of this method. PAUL STARR.

IN a volume of two hundred pages,[2] Kidd and Simpson review 650 cases of common infections of the female urethra and cervix, studied over a period of 20 years. One is greatly impressed with the careful method with which the cases have been studied from a clinical as well as a bacteriological standpoint. The discussions on gonorrhœal arthritis, prophylaxis, and general methods of diagnosis are of outstanding interest.

While intra-uterine douching and forceful vaginal douches recommended by the author will not be universally approved, nevertheless the volume as a whole is interesting, and makes very good reading. Descriptions of diseases of the external genitalia are accurate. EUGENE A. EDWARDS.

[1] THE VOLUME OF THE BLOOD AND PLASMA IN HEALTH AND DISEASE. By Leonard G. Rowntree, M.D., and George E. Brown, M.D., with the technical assistance of Grace M. Roth. Philadelphia and London: W. B. Saunders Company, 1929.

[2] COMMON INFECTIONS OF THE FEMALE URETHRA AND CERVIX. By Frank Kidd, M.A., M.Ch. (Cantab.), F.R.C.S. (Eng.), and Malcolm Simpson, B.A., M.B., D.P.H.(Cantab.). 2d ed. New York and London: Oxford University Press, 1929.

IN any treatise on radiography of uterus and tubes one naturally looks first for a reference to Kennedy whose work was the logical outcome of Rubin's ingenious design. But so short is the memory of medical men nowadays that credit is often given more from personal or nationalistic preference, and in Béclère's book,[3] salpingography, essentially an American invention, starts from the demonstration of the harmlessness of lipiodol by Sicard and Forestier, and is developed almost exclusively by French authors. I do not wish to lay unction to my soul, but it seems to me that in America we are rather punctilious in giving credit where credit is due, without regard to political boundaries.

Aside from these historical inaccuracies, however, Béclère has produced a good book, I may even say, an extremely good book on the subject. He has injected iodized oil in 270 cases and taken almost 1000 roentgenograms, of which 70 are reproduced in this volume in an excellent manner. That is an imposing material and an admirably thorough search which demand respect.

In 44 cases of sterility he found complete occlusion of both tubes in more than one-half and a diminished permeability in more than one-fourth of the cases; and only in 18 per cent were the tubes patent. In the large majority of all cases, gonorrhœa was the etiological factor. In 70 cases of salpingitis, the infection resulted in tubal occlusion in 57 per cent, and left the patency of the tubes undisturbed only in 13 per cent. Contrary to general assumption the author believes that a mild gonorrhœal infection primarily leads to hydrosalpinx, and that pyosalpinx and tubo-ovarian abscess are due to reinfection of a primary hydrosalpinx. Streptococcic infection injures the tubal mucosa far less frequently and intensely than does the gonococcus.

In sterility, oil injection should be made only after any cervical infection has been treated and definitely eliminated. The examination will then reveal, first, any abnormal condition within the uterine cavity, second, the state of the tubes and the exact location of any obstruction. Incidentally, this purely diagnostic procedure has a possible therapeutic value, since pregnancy has followed such examination in about 10 per cent of the cases. Where a tubal obstruction has been demonstrated, the roentgenogram will point the way to rational treatment. Unnecessary operations on the uterus could be excluded, and the cases would be indicated where salpingostomy or reimplantation of the tubes is required.

After the clinical cure of a salpingitis, radiography throws light on the prognosis as far as conception is concerned, and when only one tube is found patent, the other, occluded tube may be removed.

This is only the gist of Béclère's conclusions, but the interested reader—and who is not interested in

[3] LA PERMÉABILITÉ ET LES OBTURATIONS TUBAIRES; STÉRILITE, INFECTIONS SALPINGIENNES CHIRURGIE TUBAIRE. By Claude Béclère. Paris: Masson et Cie., 1929.

tubal radiography at present?—will also find many valuable hints as to the proper technique.

The final evaluation of tubal oil injections depends on their innocuousness. Of this the author is convinced, for he has had but one case of acute salpingitis in 270 patients. But he knows of one fatal case in America and half a dozen more or less serious peritoneal inflammations in France. Is that really the sum total of all complications? Are accidents as readily published as successes? The author himself warns against dangers from using too much pressure. Lastly, what becomes of the oil which oozes from the open ends of the tubes? We know from the days of August Martin and, later, Pfannenstiel that plain oil irritates the peritoneum; and *iodized* oil should be less irritating? From my own experience I can testify that in one case the oil injection first proved the patency of the tubes and then caused a pelvic peritonitis and *produced* occlusion. In 10 years, perhaps, the method will be only of historical value. For the present, however, it is intensely interesting and important, as long as we can be sure that the oil will not pass through the tubes into the peritoneal cavity.

GEORGE GELLHORN.

ONE of many textbooks of gynecology for nurses on the market, Gellhorn's[1] little book has the distinction of being the only one that gives a brief and much needed history of gynecology in addition to a simple and easily understandable discussion of the female genital organs in health and disease. Part II on gynecological nursing is especially well done, presenting the main points of methods of examination, therapeutic measures and details of pre-operative and postoperative care in a manner intelligible and helpful to the nurse interested in that aspect of medicine. The illustrations are good and do much to supplement and clarify descriptions within the text. The book is written from the point of view of the nurse and is to be highly recommended as a textbook for general use.

MARK T. GOLDSTINE.

IN the past few years a number of manuals dealing with the injection treatment of hæmorrhoids have been published. Among these the book of L. Goldbacher, *Hemorrhoids; the Injection Treatment and Pruritus Ani*[2] is worthy of mention. The first few chapters are devoted to the surgical anatomy, pathology, symptoms, and classification of the different types of hæmorrhoids. The author states that he has not observed a single recurrence of hæmorrhoids when the phenolized oil injection method has been used properly, but that he has seen the return of hæmorrhoids after surgical excision. I do not believe, however, that this is the experience of every proctologist.

A special prepared needle is used by Goldbacher, and the solution consists of 5 per cent dry phenol crystals dissolved in Wesson oil. While the technique is fully described, only a few rules to be observed will be mentioned. Only internal hæmorrhoids should be treated with this method and the injection should never be made below the mucocutaneous junction. If a pure white spot appears at the site of the injection, the needle point is too superficial. A prolapsed hæmorrhoid must not be injected until it is returned into the rectum.

As to pruritus ani, the author is of the opinion that tissue spaces and channels, often of microscopic size, exist in the peri-anal and rectal tissues. These channels convey irritating products and their discharge sets up a pruritic irritation.

The object of the treatment is to obliterate these channels. He advocates the injection of a 5 per cent phenolized oil through the perineum at the site of irritation. The needle is introduced about one-half inch from the rectum and inserted to a depth of about three-fourths of an inch and about 5 to 10 cubic centimeters is injected. This should not produce any pain, or abscess or complication of any kind.

Submucosal injections are also made, on the supposition that these channels may exist under the mucous membrane of the lower rectum. These injections are made through the anoscope. This form of treatment should not be started until the rectum has been relieved of all other rectal disease. The author reports gratifying results with this form of treatment.

C. J. DE BERE.

A POINT much in its favor is that *Clinical Obstetrics*[3] is easy to read. It is designed to supplement the usual textbook on obstetrics. Its aim is to formulate a general plan of clinical procedure in the management of an obstetrical case—a laudable undertaking. "When and why an operative measure is instituted are far more important than the facility with which it is carried out."

The chapters on Bandl's ring and breech are excellent. This does not mean that the rest of the chapters are poor, but that these two stand out particularly well. His recommendations in regard to the use of pituitary extract are good.

To some points brought out by Harper, however, the reviewer would take exception, for instance his reference to hæmostasis due to uterine retraction; his statement that it is not necessary to paint the skin and vulva with iodine or mercurochrome in the ordinarily clean case; his recommendation that nourishment be given in small amounts during labor; his suggestion to use manual dilation of the cervix in so many conditions; his statement "while it is best not to invade the infected puerperal uterus, there would seem to be no justification for an expectancy that leaves necrotic material or a removable focus of infection in place"; his neglect to mention the use of

[1] GYNECOLOGY FOR NURSES. By George Gellhorn, M.D., F.A.C.S. Philadelphia: W. B. Saunders Company, 1930.

[2] HEMORRHOIDS; THE INJECTION TREATMENT AND PRURITUS ANI. By Lawrence Goldbacher, M.D. Philadelphia: F. A. Davis Company, 1930.

[3] CLINICAL OBSTETRICS. By Paul T. Harper, Ph.B., M.D., Sc.D., F.A.C.S. Philadelphia: F. A. Davis Company, 1930.

the tracheal catheter in asphyxia of the newborn; and the lack of detail in the chapter on hyperemesis gravidarium.

In spite of these criticisms the book is well worth while. E. L. CORNELL.

THE book by T. Henry Treves-Barber on varicose veins[1] is very well written and the subject, with few exceptions, is thoroughly covered. The author is cautious in determining the indications for the injection treatment of varicose veins; in fact, he is more conservative than the majority of men doing this work either abroad or in the United States. While Dr. Treves-Barber prefers the 15 per cent solution of sodium chloride, he discusses all solutions used. He is an enthusiastic advocate of the injection treatment of varicose veins and believes that the surgical treatment is a thing of the past. He does not mention the supportive treatment of varicose veins, a method which has now passed through the experimental stage and has been found to give results far superior to those from any other method of treatment.

There is a scarcity of plates and photographs in the book, but this is not regarded by some as of great importance. No bibliography is given, but all in all the book is one of the best on the market at the present time and I believe that it is superior to any from the European press. It is well worth the price to any man doing this work. H. O. MCPHEETERS.

THE fourth edition of Jellett's *Manual of Midwifery*[2] has been thoroughly revised by Madill, an ex-assistant master of Rotunda Hospital. The volume still represents the teachings and practice of the Rotunda. The chapters on eclampsia, the treatment of contracted pelvis, the etiology of antepartum hæmorrhages have been rewritten, new sections have been added to the sections on anæsthesia during labor, pyelitis during pregnancy, nephritic toxæmia and pre-eclamptic toxæmia. New illustrations have been added here and there. The volume retains the nomenclature peculiar to English authors, in many places without reference to terms in common usage.

The reviewer feels that in the main the advice given is safe, although in a few instances he would do otherwise. The use of a metal urinary catheter in a patient in labor is rather dangerous. The advice to make vaginal, in preference to rectal, examinations is to be regretted. In the treatment of pyelitis of pregnancy no mention is made of cystoscopic examination or the insertion of the ureteral catheter. This is well recognized treatment in selected cases.

Considerable space is given to the operation of pubiotomy. It is strongly recommended as the operation of choice in certain cases of contracted pelves. Why risk a mutilating operation of this type when the low cervical cæsarean section gives such good results? The chapters on antepartum hæmorrhage and eclampsia are particularly well done.

E. L. CORNELL, M.D.

IN his recent work, *Stone in the Urinary Tract*[3] H. P. Winsbury White, a London urologist, stresses no one factor in his discussion of etiology of calculi but mentions geographical influences, variety of water, physicochemical reactions of colloids, bacterial agencies, and vitamin deficiency as possible factors.

Contrary to other contemporary workers, this author believes that many urinary calculi are not opaque to the X-ray; especially those composed of uric acid, xanthin, and cystin.

The pathology of renal stones consists of changes due to back pressure and infection. Similar to current American belief, non-interference is advised in cases of large bilateral calculi. Renal stones may be silent or manifested by fixed pain, or typical radiating renal colic or referred pain. It is surprising to note, it is contended that lining epithelial cells of the kidney pelvis can be differentiated in the urine by the microscope. Since the advent of the cystoscope and roentgen-ray, exploratories for renal calculi are unjustifiable.

Prophylactic dietary measures to be followed in various calculi are discussed. The best conservative treatment of any renal calculus is early removal. In spite of its awkwardness, the author uses fluoroscopy at the operating table. In cases of multiple urinary calculi of different location, as a rule, the one located lowest down is removed first.

The author believes that ureteral stones should be given an opportunity to pass spontaneously; if the stone is not passed, careful and deliberate cystoscopic ureteral manipulation is advised. Ureterotomies are done extra-peritoneally.

Only a few pages are devoted to the general considerations of calculous anuria.

Because of their common occurrence, vesical calculi receive ample consideration. Dr. White does not use spinal anæsthesia, because of the attendant risk to the patient. His caution not to use too much fluid in a bladder for instrumentation is very timely. If lithopaxy *per urethram* is contra-indicated, median perineal litholapaxy is advised.

Urethral stricture is the most common predisposing cause of urethral calculus. A primary urethral calculus is rare. Most stones of the anterior urethra can be removed with proper forceps. Urethrotomy can always be done. Calculi of the posterior and prostatic urethra are attacked perineally by Dr. White. Prostatic and preputial calculi are described. There are separate chapters on urinary calculi in children and pregnant women.

[1] THE TREATMENT OF VARICOSE VEINS OF THE LOWER EXTREMITIES BY INJECTION. By T. Henry Treves-Barber, M.D., B.Sc. New York: William Wood and Company, 1929.

[2] A MANUAL OF MIDWIFERY: FOR STUDENTS AND PRACTITIONERS. By Henry Jellett, B.A., M.D. (Dub. Univ.), F.R.C.P.I., L.M., and David G. Madill, B.A., M.D., B.Ch., B.A.O. (Dub. Univ.) L.M. New York: William Wood and Company, 1929.

[3] STONE IN THE URINARY TRACT. By H. P. Winsbury White, M.B., Ch.B. (Edin.), F.R.C.S. (Edin.), F.R.C.S. (Eng.). Philadelphia: P. Blakiston's Son and Company, 1929.

One seldom has the opportunity of encountering as fine a bibliography as is incorporated in this volume on stone in the urinary tract.

This book is beautifully and adequately illustrated. It affords to the physician, a working volume of principles on urinary calculi. HARRY CULVER.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

THE INTERNATIONAL MEDICAL ANNUAL; A YEAR BOOK OF TREATMENT AND PRACTITIONER'S INDEX. Edited by Carey F. Coombs, M.D., F.R.C.P. and A. Rendle Short, M.D., B.Sc., F.R.C.S. 48th year. New York: William Wood and Company, 1930.

DISEASES OF THE NOSE, THROAT AND EAR; MEDICAL AND SURGICAL. By William Lincoln Ballenger, M.D., F.A.C.S. 6th ed. rev. by Howard Charles Ballenger, M.D., F.A.C.S. Philadelphia: Lea & Febiger, 1930.

A MANUAL OF DISEASES OF THE NOSE AND THROAT. By Cornelius G. Coakley, A.M., M.D., F.A.C.S. 7th ed. rev. Philadelphia: Lea & Febiger, 1930.

PHYSIKALISCH-CHEMISCHE PROBLEME IN DER CHIRURGIE. By Dr. C. Haebler. Berlin: Julius Springer, 1930.

DIE ENTZUENDLICHEN ERKRANKUNGEN DER WEIBLICHEN GESCHLECHTSORGANE; IHR WESEN, IHRE ERKENNUNG, UND BEHANDLUNG. By Prof. Dr. C. Bucura. Vienna: Julius Springer, 1930.

LES HYDRONÉPHROSES; ANATOMIE ET PATHOGÉNIE. By Edmond Papin. Paris: G. Doin et Cie, 1930.

DER EINFLUSZ DES GESCHLECHTSVERKEHRS AUF DAS BEFINDEN DER FRAU. By Dr. Heinrich Offergeld. 2d ed. Stuttgart: Ferdinand Enke, 1930.

DIE NASE ALS REFLEXORGAN; DES AUTONOMEN NERVENSYSTEMS. By Dr. Alfred Koblanck. With foreword by Prof. Dr. Friedrich Matthaei. Berlin and Vienna: Urban & Schwarzenberg, 1930.

THE ACTION OF MUSCLES; INCLUDING MUSCLE REST AND MUSCLE RE-EDUCATION. By Sir Colin Mackenzie, M.D., F.R.C.S., F.R.S. (Edin.). 2d ed. New York: Paul B. Hoeber, Inc., 1930.

A MANUAL FOR A DEMONSTRATION COURSE IN OBSTETRICS. By Reuben Peterson, A.B., M.D., F.A.C.S. Ann Arbor, Michigan: Edwards Brothers, 1930.

A TEXT-BOOK FOR MIDWIVES. By John S. Fairbairn, M.A., B.M., B.Ch. (Oxon.), F.R.C.P. (Lond.), F.R.C.S. (Eng.). 5th ed. London and New York: Oxford University Press, 1930.

DISEASES OF THE URINARY TRACT IN CHILDREN. By Edwin Beer, M.D., and Abraham Hyman, M.D. New York: Paul B. Hoeber, Inc., 1930.

RADIUM AND CANCER (CURIETHERAPY). By Duncan C. L. Fitzwilliams, C.M.G., M.D., Ch.M., F.R.C.S. New York: William Wood & Company, 1930.

A SYNOPSIS OF SURGERY. By Ernest W. Hey Groves, M.S., M.D., B.Sc. (Lond.), F.R.C.S. (Eng.). 9th ed. New York: William Wood and Company, 1930.

NURSING IN EMERGENCIES. By Jacob K. Berman, A.B., M.D., F.A.C.S. St. Louis: The C. V. Mosby Company, 1929.

SURGICAL DIAGNOSIS. By American authors. Edited by Evarts Ambros Graham, A.B., M.D. Vol. iii; also index to vols. i to iii. Philadelphia and London: W. B. Saunders Company, 1930.

COLLECTED PAPERS OF THE MAYO CLINIC AND THE MAYO FOUNDATION FOR 1929. Vol. xxi. Edited by Mrs. Mellish, Richard M. Hewitt, B.A., M.A., M.D., and Mildred A. Felker, B.S. Philadelphia and London: W. B. Saunders Company, 1930.

SONDERBAENDE ZUR STRAHLENTHERAPIE. Vol. xiv. Tabellen zur Dosierung der Roentgenstrahlen. By Prof. Dr. L. Grebe and Dr. Phil K. Nitzge. Berlin and Vienna: Urban & Schwarzenberg, 1930.

METHODS AND PROBLEMS OF MEDICAL EDUCATION (SEVENTEENTH SERIES). New York: The Rockefeller Foundation, 1930.

CHEMISTRY IN MEDICINE; A CO-OPERATIVE TREATISE INTENDED TO GIVE EXAMPLES OF PROGRESS MADE IN MEDICINE WITH THE AID OF CHEMISTRY. Edited by Julius Stieglitz. New York: The Chemical Foundation, Inc.

SOME ASPECTS OF THE CANCER PROBLEM; AN ACCOUNT OF RESEARCHES INTO THE NATURE AND CONTROL OF MALIGNANT DISEASE COMMENCED IN THE UNIVERSITY OF LIVERPOOL IN 1905, AND CONTINUED BY THE LIVERPOOL MEDICAL RESEARCH ORGANIZATION (FORMERLY THE LIVERPOOL CANCER COMMITTEE), TOGETHER WITH SOME OF THE SCIENTIFIC PAPERS PUBLISHED. Edited by W. Blair Bell, B.S., M.D. (Lond.), F.R.C.S. (Eng.), F.A.C.S. (Hon.). New York: William Wood and Company, 1930.

CLIO MEDICA; A SERIES OF PRIMERS ON THE HISTORY OF MEDICINE. Edited by E. B. Krumbhaar, M.D. Vol. I.—The Beginnings—Egypt and Assyria. By Warren R. Dawson, F.R.S.E. Vol. II.—Medicine in the British Isles. By Sir D'Arcy Power, K.B.E., F.R.C.S. (Eng.). Vol. III. Anatomy. By George W. Corner, M.D. New York: Paul B. Hoeber, 1930.

THE SKIN REACTIONS, BLOOD CHEMISTRY AND PHYSICAL STATUS OF "NORMAL" MEN AND OF CLINICAL PATIENTS. By William F. Petersen, M.D., and Samuel A. Levinson, M.D. Chicago: American Medical Association, 1930.

COLLECTED PUBLICATIONS FROM THE ROBERT DAWSON EVANS MEMORIAL FOR CLINICAL RESEARCH AND PREVENTATIVE MEDICINE. No. 1.—Endocrine Studies. Boston: F. J. Barnard & Co., Inc., 1929.

REPORT ON FIFTH INTERNATIONAL CONGRESS OF MILITARY MEDICINE AND PHARMACY. London, England, May, 1929. By Commander William Seaman Bainbridge, M.C.-F. Menasha, Wisconsin: The Collegiate Press, 1930.

PHYSICAL DIAGNOSIS. By Richard C. Cabot, M.D. 10th rev. ed. New York: William Wood and Company, 1930.

DISEASES OF WOMEN. By ten teachers. Under the direction of Comyns Berkeley, M.A., M.D., M.C. (Cantab.), F.R.C.P. (Lond.), F.R.C.S. (Eng.). Edited by Comyns Berkeley, H. Russell Andrews, J. S. Fairbairn. 4th ed. New York: William Wood and Company, 1930.

INJURIES TO JOINTS. By Sir Robert Jones, Bart., K.B.E., C.B., Ch.M., F.R.C.S., F.A.C.S. 3d ed. New York and London: Oxford University Press, 1930.

NEW AND NONOFFICIAL REMEDIES, 1930; CONTAINING DESCRIPTIONS OF THE ARTICLES WHICH STAND ACCEPTED BY THE COUNCIL ON PHARMACY AND CHEMISTRY OF THE AMERICAN MEDICAL ASSOCIATION ON JANUARY 1, 1930. Chicago: American Medical Association, 1930.

CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

MERRITTE W. IRELAND, Washington, *President* C. JEFF MILLER, New Orleans, *President-Elect*
FRANKLIN H. MARTIN, Chicago, *Director-General*

PHILADELPHIA EXECUTIVE COMMITTEE

E. L. ELIASON, *Chairman* DRURY HINTON, *Secretary*

BROOKE M. ANSPACH	FIELDING O. LEWIS	DAMON B. PFEIFFER
LOUIS H. CLERF	GEORGE P. MULLER	JOHN S. RODMAN
JOHN D. ELLIOTT	WILLIAM J. MERRILL	WILLIAM T. SHOEMAKER
FLOYD E. KEENE	CHARLES F. NASSAU	B. A. THOMAS

PROGRAM FOR THE 1930 CLINICAL CONGRESS IN PHILADELPHIA

A PRELIMINARY program or schedule of the clinics and demonstrations to be given in the hospitals and medical schools of Philadelphia during the twentieth annual Clinical Congress of the American College of Surgeons, October 13–17, as prepared by the Committee on Arrangements, appears in the following pages. The surgeons of Philadelphia expect to provide for the visiting surgeons a complete showing of the clinical surgical activities of that great medical center, the actual program to include clinics in all branches of surgery—general surgery, gynecology, obstetrics, orthopedics, urology, surgery of the eye, ear, nose and throat. The program as here published is merely an outline or basis for the complete program for the five days' session. During the weeks preceding the Congress the program is to be revised and amplified in order to present a more complete outline of the clinical work to be demonstrated. Clinics are scheduled to begin at 2 o'clock on Monday afternoon and for the mornings and afternoons of each of the four following days.

The real program of the Congress, which will present a complete and detailed schedule of the clinics to be given at each of the hospitals together with detailed programs for all conferences, scientific sessions, etc., will be issued daily during the Congress in the form of bulletins, which will be posted at headquarters each afternoon presenting the clinical schedules for all hospitals for the following day. Printed bulletins containing the same material will be distributed each morning.

As a special feature of the clinical program, the Committee is arranging for a series of fracture clinics at several of the large hospitals demonstrating modern methods in the treatment of fractures, which forms so large a part of surgical work in large cities and industrial centers.

In the following pages will be found the program for a series of clinical demonstrations in ophthalmology and otolaryngology to be held in the ballroom of the Bellevue-Stratford Hotel each morning except Monday. These demonstrations, as arranged by a sub-committee of Philadelphia ophthalmologists and otolaryngologists, will be held in the forenoon in view of the fact that the clinical work in these specialties will be presented at the hospitals in the afternoon.

Motion picture films that have been produced under the supervision of or approved by the Board on Medical Motion Pictures will be shown at a series of film exhibitions to be conducted at headquarters daily except on Monday. A number of films will be given their premier showing in Philadelphia. There will also be shown a number of outstanding contributions not comprised in the College library of films, including several new "sound" pictures.

At the annual meeting of the College, on Thursday afternoon at 2 o'clock, formal reports on the activities of the College will be presented by the officers and several standing committees. At the conclusion of the annual meeting there will be presented a symposium on cancer dealing with the scientific aspects of this problem.

Plans for the entertainment of visiting ladies are under consideration by the Executive Committee, and it is probable that a series of automobile tours visiting the important historic points in and around Philadelphia will be arranged.

Clinical Congress headquarters will be established at the Bellevue-Stratford Hotel, corner of Broad and Walnut Streets. All of the large rooms on the first floor, including the grand ballroom which will be used for the evening scientific meetings, the hospital conference on Monday, the annual meeting and other large gatherings, together with several of the large rooms on the roof and the Stratford room on the main floor, have been reserved for the use of the Congress, and will be utilized for scientific meetings, conferences, film exhibitions, registration and ticket bureaus, bulletin boards, executive offices, scientific and technical exhibitions, etc.

Space has been reserved in the Stratford Room on the main floor, the Clover and Red Rooms and other large rooms on the first floor, for the Technical Exhibition in which will be represented the leading manufacturers of surgical instruments, X-ray apparatus, operating lights, hospital apparatus of all kinds, pharmaceuticals, publishers of medical books, etc.

EVENING MEETINGS

The Executive Committee of the Congress is preparing programs for a series of five evening meetings to be held in the ballroom of the Bellevue-Stratford Hotel. On Monday evening, at the Presidential Meeting, following the introduction of distinguished guests from abroad and the address of the retiring president, Major-General Merritte W. Ireland, Washington, the president-elect, Dr. C. Jeff Miller, of New Orleans, will deliver his inaugural address. Mr. George Grey Turner, Newcastle-on-Tyne, England, professor of surgery in the University of Durham and Hunterian professor and member of council of the Royal College of Surgeons of England, will deliver the Murphy oration in surgery on that occasion.

Among the distinguished visitors from abroad who will present papers at the scientific meetings are: William Ernest Miles, F.R.C.S., surgeon to the Gordon Hospital for Rectal Diseases and the Cancer Hospital of London, who will present a paper on "Cancer of the Rectum"; Professor Otfried Foerster, of the University of Breslau, Germany, who will discuss the surgical treatment of neurogenic contractures; Professor Emile de Grosz, of Budapest, Hungary, who will present a paper on ophthalmological surgery.

At the annual Convocation of the College on Friday evening, the 1930 class of candidates for Fellowship in the College will be received. The Fellowship address will be delivered by Dr. George W. Crile, of Cleveland, Ohio.

The annual oration on fractures will be delivered by Dr. Dallas B. Phemister, Professor of Surgery at the University of Chicago.

Three major subjects form the basis for the programs for the evening meetings: plastic surgery including the treatment of burns, injuries, contractures and congenital deformities; surgery of the kidneys, bladder and ureter; and thoracic surgery. Distinguished surgeons of the United States and Canada have been invited by the committee to present papers dealing with these subjects. A complete program for the evening meetings will be published in the next issue of this journal.

CANCER CONFERENCE

Under the auspices of the Committee on the Treatment of Malignant Diseases, with Robert B. Greenough, of Boston, Chairman, a round table conference will be held on Thursday morning on the subject of cancer clinics, cancer hospitals and cancer institutes. At this conference plans for the organization and administration of such institutes will be discussed by members of the committee who will present the methods recommended by the committee for securing more widespread efficient care for cancer patients. Opportunity will also be afforded to representatives of existing and proposed cancer clinics of the different types to present questions on the administration and professional conduct of such clinics.

On Thursday afternoon following the annual meeting and under the auspices of the same committee there will be a symposium on cancer, to include the presentation of several papers dealing with the scientific aspects of the problem. A detailed program will be published in the October issue of this journal.

Preparations are being made at some of the Philadelphia hospitals where cancer clinics are being conducted for demonstrations or dry clinics dealing with the subject of cancer.

CONFERENCE ON TRAUMATIC SURGERY

A conference on traumatic surgery is being arranged for Friday, with sessions both morning and afternoon, at which leaders in industry, education and labor, together with the representatives of indemnity companies, surgeons and hospital administrators, will discuss various phases of this activity of the College. The program for the conference includes the following:

Report on the Work of the Committee on Traumatic Surgery in Recent Years, Its Present and Future Activities. FREDERIC A. BESLEY, Waukegan, Ill., Chairman.

Injuries to the Shoulder Joint. ERNEST AMORY CODMAN, Boston.

Treatment of Injuries of the Knee Joint. WILLIS C. CAMPBELL, Memphis, Tenn.

Treatment of Fractures by Skeletal Traction. SAMUEL R. CUNNINGHAM, Oklahoma City, Okla.

Application of the Compensation Act in the State of New York. LINDSAY ROGERS, New York.

Discussion of the Automobile Accident Situation in Relation to Payment for Hospital Care. EMIL FRANKEL, Director of Research, New Jersey Department of Institutions and Agencies, Trenton, N. J.

HOSPITAL STANDARDIZATION CONFERENCE

For the thirteenth annual hospital standardization conference which opens at 9:30 o'clock on Monday morning, October 13th, in the ballroom of the Bellevue-Stratford Hotel, an interesting program of papers, round table conferences, and practical demonstrations that deal with the problems related to the hospital standardization program of the College and to hospital efficiency in general is being prepared.

Monday, 9:30–12:00

Opening Address. Major-General MERRITTE W. IRELAND, Washington; President, American College of Surgeons.

Presentation of the Thirteenth Annual Report of Hospital Standardization. FRANKLIN H. MARTIN, M.D., Chicago; Director General, American College of Surgeons.

Our Responsibility as Fellows of the College in Furthering the Hospital Standardization Movement. C. JEFF MILLER, M.D., New Orleans; President-Elect, American College of Surgeons.

What the Hospital Standardization Movement Means to the Present Day Practice of Medicine. GEORGE W. CRILE, M.D., Cleveland; Director, Cleveland Clinic.

My Conception of an Ideal Hospital. Rev. ALPHONSE M. SCHWITALLA, St. Louis; Dean, St. Louis University School of Medicine; President, Catholic Hospital Association.

Is Standardization of Hospital Surgical Procedures Possible? JOSEPH C. DOANE, M.D., Philadelphia; Director, Jewish Hospital.

The Liaison Committee—a Means of Promoting Co-operation Between the Medical Staff and the Hospital Management. J. GARLAND SHERRILL, M.D., Louisville; Visiting Surgeon, Louisville Public, Jewish, and St. Mary and St. Elizabeth Hospitals.

Monday, 2:00–5:00

FRANK D. JENNINGS, M.D., Brooklyn; Clinical Professor of Surgery, Long Island College Hospital; Surgeon, St. Catherine's Hospital, presiding.

A Study of Acute Appendicitis at St. Catherine's and Greenpoint Hospitals, Brooklyn, from 1919 to 1929 inclusive, for the Purpose of Evaluating the Benefit of Staff Conferences. JOSEPH S. BALDWIN, M.D., Attending Surgeon, Greenpoint and Holy Family Hospitals; HARRY FELDMAN, M.D., Associate Surgeon, Greenpoint Hospital; JOHN A. MCCABE, M.D., Assistant Surgeon, Greenpoint and St. Catherine's Hospitals; JOSEPH L. PFEIFER, M.D., Assistant Surgeon, St. Catherine's Hospital; WALTER J. O'CONNELL, M.D., Assistant Surgeon, St. Catherine's Hospital.

Co-ordination and Integration of the Gynecological-Obstetrical Service in a General Hospital. CHARLES A. GORDON, M.D., Brooklyn; Clinical Professor of Obstetrics and Gynecology, Long Island College Hospital; Attending Obstetrician and Gynecologist, Greenpoint and St. Catherine's Hospitals.

A Plan for the Organization and Control of the Courtesy Staff in a General Hospital. JOHN M. SCANNELL, M.D., Jamaica, N. Y.; Attending Surgeon, St. Catherine's Hospital, Brooklyn; Attending Surgeon, Mary Immaculate Hospital, Jamaica.

Problems of the Rural Surgeon and Their Solution. JOHN B. MCKENZIE, M.D., Loggieville, N. B.; Surgeon, Hotel Dieu, Chatham.

Is the Private Patient Getting a Square Deal? JOHN E. JENNINGS, M.D., Surgeon-in-Chief, Cumberland Hospital; Surgeon, Brooklyn and St. Peter's Hospitals.

Tuesday, 9:30–12:30

Important Basic Considerations in Maintaining an Adequate X-ray Service in Various Sized Hospitals. EDWARD S. BLAINE, M.D., Chicago; Radiologist, Wesley Memorial Hospital.

Autopsies, Their Value and Certain Factors that Will Influence Their Increase. B. HENRY MASON, M.D., Waterbury, Conn.; Superintendent, Waterbury Hospital.

Absorption of Special Charges in Hospitals (illustrated). LAWRENCE C. AUSTIN, Milwaukee; Superintendent, Mount Sinai Hospital.

The Hospital's Teaching Responsibility. JOHN E. RANSOM, Baltimore; Assistant Director, Johns Hopkins Hospital.

Tuesday, 2:00–5:00

Round Table Conference—Functions, Relationships, and Responsibilities of the Board of Trustees, Medical Staff, and Superintendent. Conducted by C. W. MUNGER, M.D., Valhalla, N. Y.; Director, Westchester County Department of Hospitals.

Wednesday, 9:30–12:30

Organization of the Record Department (illustrated). PAUL H. FESLER, Minneapolis; Superintendent, University Hospitals.

Centralization of Medical Statistics in the Record Department. MARY M. NEWTON, R.N., Pittsburgh; Medical Statistician, Pittsburgh Homeopathic Hospital.

Rôle of the Student Nurse in the Clinical Record. MARY MERRILL, Williamsport; Student Nurse, School of Nursing, Williamsport Hospital.

Case Records and Clinical Conferences. IRVIN D. METZGER, M.D., Pittsburgh; President, Pennsylvania State Board of Medical Education and Licensure.

Wednesday, 2:00–5:00

Round Table Conference—Medical and Hospital Economics. Conducted by ROBERT JOLLY, Houston, Texas; Superintendent, Baptist Hospital. Educating the Public; Costs versus Value of Medical and Hospital Services; Medical and Hospital Economics in relation

to planning and construction, management, scientific departments (clinical laboratory, X-ray and physical therapy); Standardization of Equipment and Supplies.

For Thursday forenoon, those attending the hospital conference are invited to attend a round table conference on the subject of cancer clinics, cancer hospitals and cancer institutes, and on Friday morning a conference on traumatic surgery. The afternoons of those two days will be devoted to visits to the Philadelphia hospitals with demonstrations on hospital equipment, construction, management, etc. All persons interested in the hospital field are invited to attend the hospital conference.

REDUCED RAILWAY FARES

The railways of the United States and Canada have authorized reduced fares on account of the Philadelphia session of the Clinical Congress so that the total fare for the round trip will be one and one-half the ordinary first-class one-way fare. To take advantage of the reduced rates it is necessary to pay the full one-way fare to Philadelphia, procuring from the ticket agent when purchasing ticket, a "convention certificate," which certificate is to be deposited at headquarters for the signature of the general manager of the Clinical Congress and the visé of a special agent of the railways. Upon presentation of a viséd certificate to the ticket agent in Philadelphia not later than October 21st a ticket for the return journey by the same route as traveled to Philadelphia may be purchased at one-half the one-way fare.

In the eastern, central and southern states and eastern provinces of Canada tickets may be purchased between October 9th and 15th; in other sections of the United States and Canada at somewhat earlier dates. The return journey from Philadelphia must be begun not later than October 21st.

The reduction in fares does not apply to Pullman fares, nor to extra fares charged for passage on certain trains. Local railroad ticket agents will supply detailed information with regard to dates of sale, rates, routes, etc. Stop-overs on both the going and return journeys may be had within certain limits.

Full fare must be paid from starting point to Philadelphia, and it is essential that a "convention certificate" be obtained from the agent from whom the ticket is purchased. These certificates are to be signed by the general manager of the Clinical Congress and viséd by a special railroad agent in Philadelphia during the meeting. No reduction in railroad fares can be secured except in compliance with the regulations outlined and within the dates specified. It is important to note that the return trip must be made by the same route as that used to Philadelphia and that the certificate must be deposited at headquarters during the meeting and return ticket purchased and used not later than October 21st.

An exception to the above arrangement is to be noted in the case of persons traveling from points in certain far western states and British Columbia, who will be able to purchase round trip summer excursion tickets which will be on sale up to and including September 30th with a final return limit of October 31st. The summer excursion fare is somewhat lower than the convention fare mentioned above, but is available only in certain of the far western states and British Columbia. Tickets sold at summer excursion rates permit traveling to Philadelphia via a direct route and returning via another direct route with liberal stop-over privileges.

SPECIAL TRAIN FROM CHICAGO

For the convenience of men living in the central and western states who will attend the Congress in Philadelphia, the Pennsylvania Railroad will undertake to provide a special train leaving Chicago at 1:45 p.m. on Sunday, October 12th, arriving in Philadelphia at 8:45 a.m. on Monday, October 13th. This special train will duplicate the equipment and schedule of the famous Broadway Limited, and will include standard Pullman sleeping, compartment, club, observation and dining cars. No extra fare will be charged for passage on this special train. Members are urged to make their reservations for the special train at the earliest possible date through their local ticket agents or by direct application to Mr. R. C. Caldwell, Division Passenger Agent, Pennsylvania Railroad, 33 North LaSalle Street, Chicago. The proposed arrangement is contingent upon reservations for such special train being made by the minimum number required by the Interstate Commerce Commission rules.

LIMITED ATTENDANCE—ADVANCE REGISTRATION

Attendance at the Philadelphia session will be limited to a number that can be comfortably accommodated at the clinics, the limit of attendance being based upon the result of a survey of the amphitheaters, operating rooms, and laboratories in the hospitals and medical schools to determine their capacity for accommodating visitors. Under this plan it will be necessary for those who wish to attend to register in advance

Attendance at all clinics and demonstrations will be controlled by means of special clinic tickets. This plan provides an efficient means for the distribution of the visiting surgeons among the several clinics, and insures against overcrowding, as the number of tickets issued for any clinic will be limited to the capacity of the room in which that clinic will be given.

REGISTRATION FEE

A registration fee of $5.00 is required of each surgeon attending the annual Clinical Congress, such fees providing the funds with which to meet the expenses of the meeting. To each surgeon registering in advance a formal receipt for the registration fee is issued, which receipt is to be exchanged for a general admission card upon registration at headquarters. This card, which is non-transferable, must be presented in order to secure clinic tickets and admission to the evening meetings.

PHILADELPHIA HOTELS AND THEIR RATES

There are ample first-class hotel facilities available in Philadelphia for all who will attend, as in recent years a number of fine hotels have been built. Many of the hotels are located within walking distance of the headquarters hotel. The following hotels are recommended by the Committee on Arrangements:

	Minimum Rates with Bath	
	Single Room	Double Room
Adelphia, 13th and Chestnut Sts	$ 4.00	$ 7.00
Barclay, Rittenhouse Square East	6.00	8.00
Bartram, 33rd and Chestnut Sts		8.00
Belgravia, 1811 Chestnut St	4.00	7.00
Bellevue-Stratford, Broad and Walnut	5.00	7.00
Benjamin Franklin, 9th and Chestnut	4.00	7.00
Colonial, 11th and Spruce Sts	4.00	7.00
Drake, 1512 Spruce St	5.00	8.00
Elks, Broad and Vine Sts	2.50	5.00
Gladstone, 11th and Pine Sts	4.00	7.00
Green's, 8th and Chestnut Sts	3.00	4.50
Lorraine, Broad and Fairmount Ave	5.00	9.00
Maidstone, 1327 Spruce St	3.00	5.00
Majestic, Broad and Girard Ave	4.00	6.00
Mayfair, Lincoln Drive and Johnson St	5.00	8.00
Pennsylvania, 39th and Chestnut Sts	3.00	5.00
Rittenhouse, 22nd and Chestnut Sts	3.00	5.00
Ritz-Carlton, Broad and Walnut Sts	6.00	10.00
Robert Morris, 17th and Arch Sts	3.50	5.00
St. James, 13th and Walnut Sts	3.50	5.00
Stephen Girard, 2027 Chestnut St	3.00	5.00
Sylvania, Juniper and Locust Sts	4.00	8.00
Tracy, 36th above Chestnut St	3.00	5.00
Walton, Broad and Locust Sts	3.50	5.00
Warwick, 17th and Locust Sts	5.00	8.00
Wellington, 19th and Walnut Sts	5.00	6.00
Westbury, 15th and Spruce Sts	5.00	10.00

PRELIMINARY CLINICAL PROGRAM

GENERAL SURGERY, GYNECOLOGY, OBSTETRICS, UROLOGY, ORTHOPEDICS

TEMPLE UNIVERSITY HOSPITAL

Monday

WILLIAM A. STEEL—1. Surgical operations.
W. HERSEY THOMAS—3. Genito-urinary surgery.
TEMPLE FAY—3. Surgical treatment of epilepsy.
EUGENE P. PENDERGRASS—3. Surgical radiologic conference, roentgenologic diagnosis of hypertrophied gastric mucosa and pedunculated tumors of the stomach prolapsing into the duodenum.
FRANK W. KONZELMAN—4. Surgical pathological conference.

Tuesday

TEMPLE FAY—9. Neurosurgical clinic, encephalography.
W. WAYNE BABCOCK—10. General surgical operations.
FRANK C. HAMMOND, H. DUNCAN and C. S. MILLER—11. Operative gynecology.
HARRY HUDSON—1. Orthopedic surgery.
TEMPLE FAY—3. Management of traumatic injuries to the brain.
EUGENE P. PENDERGRASS—3. Surgical radiological conference, roentgenologic diagnosis of liver abscess and subdiaphragmatic collections.
FRANK W. KONZELMAN—4. Surgical pathological conference.

Wednesday

WILLIAM N. PARKINSON—9. General surgical operations.
TEMPLE FAY—9. Neurosurgical clinic, spinal cord tumor cases.
W. WAYNE BABCOCK—10. General surgical operations.
LOUIS COHEN—10. Artificial pneumothorax on ambulant patients.
FRANK C. HAMMOND, H. DUNCAN and C. S. MILLER—12. Operative gynecology.
WILLIAM A. STEEL—1. General surgical operations.
H. Z. HIRSHMAN—3. Atypical neuralgia and trigeminal neuralgia.
EUGENE P. PENDERGRASS—3. Surgical radiological conference, roentgenologic study of the neck and upper respiratory tract.
FRANK W. KONZELMAN—4. Surgical pathological conference.

Thursday

TEMPLE FAY—9. Neurosurgical clinic, cerebellar tumor cases.
W. WAYNE BABCOCK—10. General surgical operations.
FRANK C. HAMMOND, H. DUNCAN and C. S. MILLER—12. Operative gynecology.
WILLIAM A. STEEL—12. Buerger's clinic, operative and ambulant cases.
JESSE ARNOLD—1. Obstetrics.
TEMPLE FAY—3. Neurosurgical clinic, hydration states, normal in eclampsia and uremia, and acute toxic states.
EUGENE P. PENDERGRASS—3. Surgical radiological conference.
FRANK W. KONZELMAN—4. Surgical pathological conference.

Friday

WILLIAM N. PARKINSON—9. General surgical operations.
TEMPLE FAY—9. Neurosurgical clinic, gangliectomy or sympathectomy.
W. WAYNE BABCOCK—10. General surgical operations.
LOUIS COHEN—10. Artificial pneumothorax on ambulant patients.
FRANK C. HAMMOND, H. DUNCAN and C. S. MILLER—12. Operative gynecology.
WILLIAM A. STEEL—1. Operative surgery.
W. HERSEY THOMAS—3. Genito-urinary operations.
TEMPLE FAY—3. Neurosurgical clinic.
EUGENE P. PENDERGRASS—3. Surgical radiological conference, encephalography.
FRANK W. KONZELMAN—4. Surgical pathological conference.

JEFFERSON HOSPITAL

Tuesday

P. BROOKE BLAND and staff—9. Gynecology and obstetrics.
J. TORRANCE RUGH and staff—10. Orthopedics.
J. CHALMERS DA COSTA and staff—11. General surgery.
THOMAS C. STELLWAGEN and staff—11. Genito-urinary surgery.
JOHN H. GIBBON and staff—2. General surgery.

Wednesday

BROOKE M. ANSPACH and staff—9. Gynecology.
P. BROOKE BLAND and staff—9. Gynecology and obstetrics.
THOMAS C. STELLWAGEN and staff—11. Genito-urinary surgery.
J. CHALMERS DA COSTA and staff—2. General surgery.

Thursday

P. BROOKE BLAND and staff—9. Gynecology and obstetrics.
THOMAS C. STELLWAGEN and staff—10. Genito-urinary surgery.
J. CHALMERS DA COSTA and staff—11. General surgery.
J. TORRANCE RUGH and staff—11. Orthopedic surgery.
P. BROOKE BLAND and staff—4. Obstetrics.

Friday

BROOKE M. ANSPACH and staff—9. Gynecology.
P. BROOKE BLAND and staff—9. Gynecology and obstetrics.
THOMAS C. STELLWAGEN and staff—11. Genito-urinary surgery.
JOHN H. GIBBON—11. General surgery.

U. S. NAVAL HOSPITAL

Tuesday

Staff—9. Surgical operations.

Wednesday

Staff—9. Surgical operations.

Thursday

Staff—9. Surgical operations.

Friday

Staff—2. Discussion of surgical cases or surgical topics.

UNIVERSITY HOSPITAL

Tuesday

CHARLES C. NORRIS, C. A. BEHNEY and D. P. MURPHY—9. Gynecological operations and demonstration of cases.

DRS. MULLER, OVERHOLT and RADEMAKER—9. Surgical clinic, abdominal cases.

EDMUND B. PIPER and staff—9. Obstetrical operations.

C. H. FRAZIER and F. C. GRANT—9. Neurosurgical clinic.

DRS. MULLER, OVERHOLT and RADEMAKER—2. Dry clinic: Special tests used in the study of vascular disturbances; opaque solutions available in the roentgenological study of surgical patients; factors in the production of chills following intravenous infusions; intraperitoneal and intrapleural pressure relationships; the course of events in acute appendicitis.

I. S. RAVDIN—2. Gall bladder surgery, operations and demonstration of cases.

C. H. FRAZIER and F. C. GRANT—2:30. Neurosurgical clinic, demonstration of interesting cases.

Wednesday

FLOYD E. KEENE and staff—9. Gynecological operations.

E. L. ELIASON and staff—9. General surgical clinic.

F. C. GRANT—9. Neurosurgical clinic.

A. BRUCE GILL and staff—2. Orthopedic surgery, dry clinic with demonstration of end results.

Thursday

C. H. FRAZIER and F. C. GRANT—9. Neurosurgical operations.

DRS. MULLER, OVERHOLT and RADEMAKER—9. Surgical clinic, thoracic cases, operations and demonstration of cases.

EDMUND B. PIPER and staff—9. Obstetrical operations.

DRS. MULLER, OVERHOLT and RADEMAKER—2. Dry clinic: Results in the surgical treatment of lung abscess; methods of treating empyema; presentation of "follow-up" chest cases of lung abscess, bronchiectasis, chronic empyema and pulmonary tuberculosis.

A. BRUCE GILL and staff—2. Orthopedic operations.

B. J. ALPERS—2:30. Neuropathological conference.

Friday

C. H. FRAZIER—9. Neurosurgical clinic.

FLOYD E. KEENE and staff—9. Gynecological operations.

EDMUND B. PIPER—9. Obstetrical operations.

E. L. ELIASON and staff—9. Fracture clinic.

ST. AGNES HOSPITAL

Monday

WILBUR HAINES and F. MICELI—2. Urological clinic.

Tuesday

E. C. MURPHY—9. General surgical clinic.

LEONARD AVERETT—10. Gynecological clinic.

Wednesday

J. W. BRANSFIELD—9. General surgical clinic.

G. M. DORRANCE—2. General surgery and cleft palate clinic.

WILBUR HAINES—2. Urological surgery.

Thursday

J. F. X. JONES—9. General surgical clinic.

JOHN A. MCGLINN—10. Gynecological clinic.

W. W. VAN DOLSEN—11. Obstetrical clinic.

Friday

G. M. DORRANCE—9. General surgical clinic.

WILBUR HAINES and F. MICELI—2. Urological clinic.

LANKENAU HOSPITAL

Monday

JOHN B. DEAVER—12. General surgical clinic.

WILLIAM MACKINNEY—3. Cystoscopy.

Tuesday

STANLEY REIMANN and staff—9. Exhibit of pathological specimens and demonstration of laboratory tests.

DR. HAMMETT—9. Chemistry of cell division.

MRS. MCNETT—9. Exhibition of drawings of pathological specimens.

MISS JASTROW—11. Exhibition of follow-up service.

ROBERT SHOEMAKER—11. X-ray demonstration.

Wednesday

STANLEY REIMANN and staff—9. Exhibit of pathological specimens and demonstration of laboratory tests.

DR. HAMMETT—9. Chemistry of cell division.

MRS. MCNETT—9. Exhibition of drawings of pathological specimens.

COLBY ENGEL—9. Injection treatment of varicose veins.

MISS JASTROW—11. Exhibition of follow-up service.

ROBERT SHOEMAKER—11. X-ray demonstration.

JOHN B. DEAVER—12. General surgical clinic.

Thursday

STANLEY REIMANN and staff—9. Exhibit of pathological specimens and demonstration of laboratory tests.

DR. HAMMETT—9. Chemistry of cell division.

MRS. MCNETT—9. Exhibition of drawings of pathological specimens.

MISS JASTROW—11. Exhibition of follow-up service.

ROBERT SHOEMAKER—11. X-ray demonstration.

JOHN B. DEAVER—12. General surgical clinic.

Friday

COLBY ENGEL—9. Injection treatment of varicose veins.

STANLEY REIMANN and staff—9. Exhibit of pathological specimens and demonstration of laboratory tests.

DR. HAMMETT—9. Chemistry of cell division.

MRS. MCNETT—9. Exhibition of drawings of pathological specimens.

MISS JASTROW—11. Exhibition of follow-up service.

ROBERT SHOEMAKER—11. X-ray demonstration.

WILLIAM MACKINNEY—3. Cystoscopy.

MT. SINAI HOSPITAL

Monday

MOSES BEHREND—1:15. General surgical operations.

Tuesday

BENJAMIN LIPSHUTZ—9. General surgical operations.

ALEXANDER RANDALL—1:30. Urological clinic, operations and demonstration of cases.

Wednesday

CHARLES MAZER—9. Operative gynecology.

MORRIS COOPERMAN—2. Orthopedic clinic, operations and demonstration of cases.

Thursday

BERNARD MANN—9. Operative gynecology.

ALEXANDER RANDALL—1:30. Urological clinic, operations and demonstration of cases.

Friday

BENJAMIN LIPSHUTZ—9. General surgical operations and demonstration of cases.

MOSES BEHREND—1. General surgical operations and demonstration of cases.

COOPER HOSPITAL

(Camden)

Tuesday

P. M. MECRAY, A. S. ROSS, F. W. SHAFER, and I. E. DEIBERT—9. General surgical operations.
T. B. LEE, A. B. DAVIS, and G. F. WEST—9. Operative gynecology and obstetrics.
I. E. DEIBERT and R. S. GAMON—10. Fracture clinic.

Wednesday

P. M. MECRAY, A. S. ROSS, F. W. SHAFER, and I. E. DEIBERT—9. General surgical operations.
B. F. BUZBY—9. Operative orthopedics.
A. H. LIPPINCOTT and D. F. BENTLEY—2. Urological operations.
P. M. MECRAY, A. S. ROSS, F. W. SHAFER, and I. E. DEIBERT—2. End results in fracture cases.
B. F. BUZBY—3. Demonstration of orthopedic cast and end results.

Thursday

P. M. MECRAY, A. S. ROSS, F. W. SHAFER, and I. E. DEIBERT—9. General surgical operations.
T. B. LEE, A. B. DAVIS, and G. F. WEST—9. Operative gynecology and obstetrics.
A. S. ROSS—2. End results in industrial injuries (New Jersey State Clinic).

Friday

P. M. MECRAY, A. S. ROSS, F. W. SHAFER, and I. E. DEIBERT—9. General surgical operations.
B. F. BUZBY—9. Operative orthopedics.
I. E. DEIBERT and R. S. GAMON—10. Fracture clinic.

HAHNEMANN HOSPITAL

Monday

H. P. LEOPOLD—2. Hernia clinic.
D. B. JAMES and staff—2. Operative gynecology.

Tuesday

A. B. WEBSTER—9. Fracture clinic.
JOHN E. JAMES and staff—2. Obstetrics.
L. T. ASHCRAFT and staff—2. Genito-urinary surgery.

Wednesday

L. T. ASHCRAFT and FRANK BENSON—9. Neoplasms of the genito-urinary tract.
H. L. NORTHROP—2. General surgical clinic.

Thursday

J. DEAN ELLIOTT—9. General surgical clinic.
D. B. JAMES and staff—9. Operative gynecology.
JOHN A. BROOKE and staff—2. Dry clinic, orthopedic surgery.

Friday

H. L. NORTHROP and staff—9. General surgical clinic.
FRANK BENSON—9. Indications for radium treatment.

BABIES HOSPITAL

Tuesday

JOHN SINCLAIR and WILLIAM BATES—2:30. Presentation of follow-up cases of intussusception and congenital hypertrophic stenosis.

Thursday

JOHN SINCLAIR and I. BINDER—2:30. Conservative treatment of cervical adenitis.

EPISCOPAL HOSPITAL

Monday

H. C. DEAVER—1:30. General surgical clinic.

Tuesday

LOUIS H. MUTSCHLER—11:30. General surgical clinic.
JOHN B. HAINES—2. Urological clinic.
TEMPLE FAY—2. Neurosurgical clinic.

Wednesday

A. P. C. ASHHURST—9. General surgical clinic.
R. L. JOHN—1:30. Orthopedic clinic.
R. S. BROMER—2. X-ray demonstration.

Thursday

ROBERT H. IVY—9. Oral surgery.
E. G. ALEXANDER—9. General surgical clinic.
H. C. DEAVER—1:30. General surgical clinic.

Friday

LOUIS H. MUTSCHLER—11:30. General surgical clinic.
JOHN B. HAINES—2. Urological clinic.

PRESBYTERIAN HOSPITAL

Tuesday

E. B. HODGE and H. P. BROWN—9. General surgery.
A. B. GILL and T. ORR—2. Orthopedics.

Wednesday

D. B. PFEIFFER and J. S. RODMAN—9. General surgery.
B. A. THOMAS, J. C. BIRDSALL and F. G. HARRISON—2. Genito-urinary surgery.

Thursday

J. H. JOPSON and W. E. CHRISTIE—9. General surgical operations.
J. H. GIRVIN, G. M. LAWS and J. P. LEWIS—2. Gynecological operations.

Friday

J. SPEESE and F. A. BOTHE—9. General surgery.

WOMAN'S MEDICAL COLLEGE HOSPITAL

Tuesday

HUBLEY R. OWEN—9. General surgery.

Wednesday

MARGARET C. STURGIS—9. Demonstration of the use of carbon dioxide tubal insufflation and uterosalpingograms in the diagnosis of sterility.

Thursday

CATHARINE MACFARLANE—9. Gynecological clinic.

Friday

JOHN S. RODMAN—9. General surgery.

ORTHOPEDIC HOSPITAL

Tuesday

A. P. C. ASHHURST, R. L. JOHN and E. T. CROSSAN—1. Out-patient clinic.
A. B. GILL—9. Orthopedic operations.

Thursday

A. P. C. ASHHURST—9. Orthopedic operations.
WILLIAM J. TAYLOR—1. Out-patient clinic.

Friday

WILLIAM J. TAYLOR—1. Orthopedic operations.

GRADUATE HOSPITAL

Monday

GEORGE E. PFAHLER—2. Radiation in diagnosis of malignant diseases.
GEORGE PIERSOL—2. Dry clinic: Cardiorenal cases.
ORLANDO PETTY—4. Demonstration of diabetes cases.

Tuesday

H. L. BOCKUS—9. Gastro-intestinal diagnosis.
WALTER E. LEE—9. General surgical clinic.
B. A. THOMAS—2. Genito-urinary operations.

Wednesday

JOHN P. JOPSON—9. General surgery.
H. L. BOCKUS—2. Gastro-intestinal diagnosis.
EUGENE A. CASE—2. Surgical pathology.
GEORGE PIERSOL—2. Dry clinic: Cardiorenal cases.

Thursday

EUGENE A. CASE—2. Surgical pathology.
C. F. MARTIN and W. O. HERMANCE—9. Rectal infections.

Friday

J. B. CARNETT—9. General surgical clinic.
B. A. THOMAS—2. Genito-urinary operations.
GEORGE PIERSOL—2. Dry clinic: Cardiorenal cases.
GEORGE E. PFAHLER—2. Radiation in diagnosis and treatment of malignant diseases.

ST. JOSEPH'S HOSPITAL

Monday

FRANCIS J. MCCULLOUGH—3. Obstetrical clinic.

Tuesday

MELVIN M. FRANKLIN—9. Fractures in children.
F. HURST MAIER—10. Gynecological operations.

Wednesday

JAMES A. KELLY—9. General surgical clinic.
JOHN F. X. JONES—9. General surgical clinic.

Thursday

ALEXANDER E. BURKE—8. Gynecological surgery.
F. HURST MAIER—10. Gynecological surgery.
CHARLES F. NASSAU—10. General surgery.

Friday

MELVIN M. FRANKLIN—9. Surgery of children.
FRANCIS J. MCCULLOUGH—3. Obstetrical clinic.

ST. MARY'S HOSPITAL

Tuesday

JAMES A. KELLY—9. General surgery.
WILLIAM J. RYAN—9. General surgery.
WILLIAM E. PARKE—1. Obstetrical clinic.

Wednesday

A. P. KEEGAN—9. General surgery.
WILLIAM MORRISON—9. Gynecology.

Thursday

HENRY K. SEELAUS—9. General surgery.
JOSEPH TOLAND—9. Gynecology.
J. STUART LAWRANCE—1. Obstetrical clinic.

Friday

P. A. MCCARTHY—9. General surgery.
LEO WOJCZYNSKI—9. Gynecology.

MISERICORDIA HOSPITAL

Tuesday

J. A. KELLY and B. R. BELTRAN—9. General surgical operations.
F. MOGAVERO—11. Pre- and postoperative care.

Wednesday

G. P. MULLER and T. RYAN—9. General surgical operations.
DR. DOUGHERTY—11. Fractures of the femur.

Thursday

J. A. KELLY and B. R. BELTRAN—9. General surgical operations.
J. A. SHARKEY and D. C. GEIST—11. Blood transfusion; operative results in fractures.

Friday

G. P. MULLER and T. RYAN—9. General surgical operations.
J. B. CARDONE and E. J. GARVIN—11. General surgical clinic.

PHILADELPHIA GENERAL HOSPITAL

Tuesday

M. P. WARMUTH—9. General surgery.
FRANK C. HAMMOND—9. Gynecology and obstetrics.

Wednesday

J. T. RUGH—9. Orthopedics.
HUBLEY OWEN—2. General surgery.

Thursday

JOHN O. BOWER—9. General surgery.
E. A. SCHUMANN—9. Gynecology and obstetrics.
WILLIAM H. MACKINNEY—2. Genito-urinary surgery.

Friday

HARVEY M. RIGHTER—9. General surgery.
Staff—2. X-ray demonstration.

METHODIST EPISCOPAL HOSPITAL

Tuesday

DAMON B. PFEIFFER and CALVIN M. SMYTH, JR.—9. General surgical operations.

Wednesday

JOHN C. HIRST and LEONARD HAMBLOCK—9. Operative gynecology and obstetrics.
JAMES H. BALDWIN—9. General surgical operations.

Thursday

GEORGE SCHWARTZ—9. General surgical operations.

Friday

DAMON B. PFEIFFER and CALVIN M. SMYTH, JR.—9. General surgical operations.

KENSINGTON HOSPITAL FOR WOMEN

Tuesday

H. C. DEAVER—12. General surgery.

Wednesday

WILLIAM E. PARKE—10. General surgery.
JOHN B. HAINES—3:30 Cystoscopic clinic.

Friday

H. C. DEAVER—12. General surgery.

ST. LUKE'S AND CHILDREN'S HOMEOPATHIC HOSPITAL

Tuesday

A. B. Webster—9. Surgical clinic.
Warren C. Mercer and staff—9. Obstetrical clinic.

Wednesday

Herbert P. Leopold and staff—9. Surgical clinic.
William C. Hunsicker and staff—9. Urological clinic.

Thursday

H. K. Roessler—9. Surgical clinic.
Richard W. Larer, John A. Brooke and staff—9. Orthopedic clinic.
James D. Schofield and staff—9. Clinic on diseases of the rectum.
Weston D. Bayley and associates—2. Neurosurgical symposium on injuries of the head.
Frank C. Benson and staff—2. Dry clinic: Indications and contra-indications for use of radium in myopathic hæmorrhage.
G. Morris Golden and group—2. Dry clinic and symposium on pre- and postoperative problems of toxic goiter.

NORTHWESTERN GENERAL HOSPITAL

Monday

J. S. Raudenbush—2. Gynecology.

Tuesday

J. B. Mencke, Robert Boyer and E. B. Parker—9. General surgical operations.
Arthur D. Kurtz—2:30. Orthopedic clinic.

Wednesday

J. B. Mencke, Robert Boyer and E. B. Parker—9. General surgical operations.
J. S. Raudenbush—12. Gynecology.
E. C. Davis—3. Rectal clinic.

Thursday

J. B. Mencke, Robert Boyer and E. B. Parker—9. General surgical operations.
L. F. Milliken—2:30. Genito-urinary surgery.

JEANES HOSPITAL

Wednesday

R. W. Teahan—2. Carcinoma of breast.
C. A. Whitcomb—2. Lung tumors.
E. E. Downs—2. The saturation method of X-ray treatment.
W. S. Hastings—2. Exhibition of interesting pathological specimens.

Thursday

R. W. Teahan—2. Carcinoma of skin.
C. A. Whitcomb—2. Mediastinal masses.
E. E. Downs—2. Exhibition of interesting X-ray films.
W. S. Hastings—2. Exhibition of interesting pathological specimens.

WOMAN'S HOMEOPATHIC HOSPITAL

Tuesday

Francois L. Hughes—9. Gynecological clinic.

Wednesday

Arthur Hartley—9. General surgical clinic.

JEWISH HOSPITAL

Tuesday

Philip Williams and E. Schumann—9. Operative gynecology.
Ralph Goldsmith—10. Fracture clinic.
William H. Keller—2. General surgical operations.

Wednesday

Frank B. Block—9. General surgical operations.
Moses Behrend—11. General surgical clinic.
Thomas Stellwagen and John B. Lownes—2. Urological operations.
Leon Brinkmann—2. General surgical operations.

Thursday

Moses Behrend—9. General surgical clinic, moving pictures; gastro-enterological cases.

Friday

Philip Williams and E. Schumann—9. Operative gynecology.
Ralph Goldsmith—10. Fracture clinic.
William H. Keller—2. General surgical operations.

PENNSYLVANIA HOSPITAL

Tuesday

Charles F. Mitchell and associates—9. Surgical clinic.

Wednesday

John H. Gibbon and associates—9. Surgical clinic.

Thursday

Charles F. Mitchell and associates—9. Surgical clinic.

Friday

John H. Gibbon and associates—9. Surgical clinic.

WOMAN'S SOUTHERN HOMEOPATHIC HOSPITAL

Tuesday

John Dean Elliott, T. C. Geary and Thomas Doyle—9. General surgical clinic.
Leon T. Ashcraft—2. Urological surgery.

Wednesday

John A. Brooke—2. Orthopedic surgery.

Thursday

Nathaniel F. Lane—2. Gynecological clinic.
Newlin F. Paxson—2. Lipiodol study of fallopian tubes.

Friday

Warren C. Mercer—2. Postnatal clinic.

GERMANTOWN HOSPITAL

Wednesday

William B. Swartley—10. General surgery.

Friday

William B. Swartley—10. General surgery.

ST. CHRISTOPHER'S HOSPITAL

Tuesday

Staff—10. General surgery.

Friday

R. L. John—10. Orthopedics.

CHILDREN'S HOSPITAL

WALTER ESTELL LEE. Surgical clinic.
WILLIAM A. JAQUETTE. Dental clinic.
HOWARD CHILDS CARPENTER. Preventive medicine in reference to surgical diseases in children.
SUSAN C. FRANCIS, R. N. Hospital management from surgical viewpoint.
J. C. GITTINGS. Medical aspect of surgical cases in children.
RALPH S. BROMER. Roentgenological aspect of children's diseases.
EDWARD F. CORSON. Bone syphilis and other allied surgical conditions.
C. C. NORRIS. Vaginitis clinic.

WOMAN'S HOSPITAL

Tuesday

EMILY W. AUGE—9. General surgery.

Wednesday

FAITH S. FETTERMAN—9. Cystoscopic demonstration.

Thursday

LIDA S. COGILL—2. Obstetrical demonstration.

Friday

MARIE FORMAD—9. Gynecological clinic.

EVANS DENTAL INSTITUTE

Tuesday

ROBERT H. IVY—9. Fracture of the jaw.

Wednesday

LAWRENCE CURTIS—9. Oral surgical clinic.

Thursday

ROBERT H. IVY and LAWRENCE CURTIS—9. Oral surgical clinic.

NORTHEASTERN HOSPITAL

Tuesday

E. C. DAVIS—2. Proctology.
T. T. THOMAS and J. C. SCOTT—3. Dry clinic, fractures and dislocations.

Wednesday

J. B. LOWNES—4. Genito-urinary surgery.

Thursday

J. S. RAUDENBUSH—2. Gynecology and obstetrics.
T. T. THOMAS—3. General surgery.

AMERICAN ONCOLOGIC HOSPITAL

Tuesday

ALBERT E. BOTHE, CHARLES E. CODMAN, GEORGE M. DORRANCE, WILLIAM C. HUEPER, BRADY A. HUGHES, C. B. LONGENECKER, SAMUEL MCCLARY III, ELLICE MCDONALD, WILLIAM S. NEWCOMET, DAMON B. PFEIFFER, WILLIAM D. ROBINSON, JESSE W. SMITH, WILLIAM H. SPENCER and S. E. TRACY—9. Clinical conference with exhibition of patients: Fibroid tumors, breast cases, congenital mouth cases, hemangiomas, etc.

STETSON HOSPITAL

Monday

CARL F. KOENIG—1:30. X-ray demonstration.

Tuesday

WILLIAM T. ELLIS and JOHN A. BOGER—12. General surgery.

Wednesday

STEPHEN E. TRACY—8:30. Gynecology.
CARL F. KOENIG—1:30. X-ray demonstration.

Friday

STEPHEN E. TRACY—8:30. Gynecology.
CARL F. KOENIG—1:30. X-ray demonstration.

CHESTNUT HILL HOSPITAL

Tuesday

JOHN MCCLOSKEY—10:30. General surgical clinic.
DRS. SCHUMANN, BARRETT and TOWSON—11. Operative obstetrics.

Thursday

CHARLES BEHNEY—9. Operative gynecology.
ALEXANDER RANDALL—9. Urological clinic.

Friday

W. C. SHEEHAN and L. HERGESHEIMER—9. General surgery.
DRS. SCHUMANN, BARRETT and TOWSON—11. Operative obstetrics.

PENNSYLVANIA HOSPITAL

(Maternity Department and Lying-In Hospital)

Tuesday

N. W. VAUX and staff—9. Obstetrics and gynecology.

Wednesday

E. B. PIPER and staff—9. Obstetrics and gynecology.

Thursday

N. W. VAUX and staff—9. Obstetrics and gynecology.

Friday

E. B. PIPER and staff—9. Obstetrics and gynecology.

FRANKFORD HOSPITAL

Tuesday

C. F. NASSAU, L. D. ENGLERTH and B. CHANDLEE—9. General surgery.

Wednesday

EDWARD SCHUMANN and FREDERICK KELLER—9. Gynecological clinic.

Thursday

W. E. PARKE—9. Gynecological clinic.
GEORGE HANNA—9. Obstetrical clinic.
L. D. ENGLERTH and B. CHANDLEE—2. Fracture clinic.

SURGERY OF THE EYE, EAR, NOSE AND THROAT

CLINICAL DEMONSTRATIONS

(Ballroom, Bellevue-Stratford Hotel)

Tuesday, 9 a.m.

Indications for and Technique of the Different Operations for Chronic Mastoiditis (lantern slide demonstration). J. Morrisset Smith, M.D., New York.
Discussion: J. Clarence Keeler, M.D., Philadelphia.

Chronic Suppurative Otitis Media. George L. Tobey, M.D., Boston.
Discussion: George M. Coates, M.D., Philadelphia.

What Place Have Operative Procedures in Otology? John F. Barnhill, M.D., Indianapolis.
Discussion: George B. Wood, M.D., Philadelphia.

Preparation for Ophthalmic Practice. Edward Jackson, M.D., Denver.
Discussion: T. B. Holloway, M.D., Philadelphia.

Wednesday, 9 a.m.

Practical Application of Bacteriology to Clinical Ophthalmology. S. Hanford McKee, M.D., Montreal.
Discussion: John A. Kolmer, M.D., Philadelphia.

Cataract Extraction, a Study of Details. Walter B. Lancaster, M.D., Boston.

Cataract Extraction (moving picture demonstration). Frank Parker, M.D., Norristown, Pa
Discussion: Eugene M. Blake, M.D., New Haven, Conn., and Luther C. Peter, M.D., Philadelphia.

Some Factors Concerned in the Success of Operations for Glaucoma. Jonas Friedenwald, M.D., Baltimore.
Discussion: William Zentmayer, M.D., and Francis H. Adler, M.D., Philadelphia.

Thursday, 9 a.m.

Plastic Facial Work. Vilray P. Blair, M.D., St. Louis.
Discussion: Robert H. Ivy, M.D., Philadelphia.

Rare Types of Carcinoma and Conditions Simulating Carcinoma (lantern slide demonstration). John E. Mackenty, M.D., New York.

Early Diagnosis and Treatment of Malignancy of the Laryngopharynx. Henry Boylan Orton, M.D., Newark, N.J.
Discussion: Fielding O. Lewis, M.D., Philadelphia.

Treatment of Tic Douloureux and Ménière's Disease. Walter E. Dandy, M.D., Baltimore.
Discussion: Francis C. Grant, M.D., Philadelphia.

Friday, 9 a.m.

Symposium on Sinus Thrombosis

Rhinological Aspects. E. Ross Faulkner, M.D., New York.

Otological Aspects. Wells P. Eagleton, M.D., Newark, N. J.

Ophthalmological Aspects. W. L. Benedict, M.D., Rochester, Minn.

Neurosurgical Aspects. Professor Otfried Foerster, Breslau, Germany.
Discussion: George M. Coates, M.D., Ralph Butler, M.D., Philadelphia, and Professor Emile v. Grosz, Budapest, Hungary.

TEMPLE UNIVERSITY HOSPITAL

Monday

Matthew Ersner—3. Operative otology.

Tuesday

Chevalier Jackson and associates—8:30. Bronchoscopic clinic.
Robert Ridpath—2. Laryngological clinic.
Luther C. Peter—3. Operative ophthalmology.

Wednesday

Chevalier Jackson and associates—8:30. Bronchoscopic clinic.

Thursday

Chevalier Jackson and associates—8:30. Bronchoscopic clinic.
Robert Ridpath—2. Operative laryngology.
Luther C. Peter—4. Ophthalmological surgery.

Friday

Chevalier Jackson—8:30. Bronchoscopic clinic.
Matthew Ersner—4. Otological clinic.

MT. SINAI HOSPITAL

Monday

C. W. LeFever—3:30. Eye clinic, operations and demonstration of cases.

Tuesday

Lewis Fisher—1. Ear, nose and throat clinic, operations and demonstration of cases.

Wednesday

David Husik—2:30. Ear, nose and throat clinic.
Gabriel Tucker—4. Bronchoscopy.

Thursday

Morris Weinstein—2. Ear, nose and throat clinic, operations and demonstration of cases.

Friday

Matthew Ersner—1. Ear, nose and throat clinic, operations and demonstration of cases.

HAHNEMANN HOSPITAL

Tuesday

H. S. Weaver and staff—2. Ear, nose and throat clinic.

Thursday

H. S. Weaver and staff—2. Ear, nose and throat clinic.

Friday

Frank Nagle and Fred Peters—9. Cataract operations.

FRANKFORD HOSPITAL

Tuesday

Frank Embery and Robert Watt—2. Ear, nose and throat clinic.

Wednesday

William H. Chandlee—2. Eye clinic.
Dr. Richardson—2. Ear, nose and throat clinic.

ST. CHRISTOPHER'S HOSPITAL

Monday

H. J. Williams or E. H. Campbell—1:30. Nose and throat clinic.

Wednesday

H. J. Williams or E. H. Campbell—9. Nose and throat clinic.

Thursday

Dr. Feldman—10. Eye clinic.

Friday

H. J. Williams or E. H. Campbell—1:30. Nose and throat clinic.

LANKENAU HOSPITAL

Monday

W. J. Creighton and Dr. Smith—1. Eye clinic.

Tuesday

W. J. Creighton and Dr. Smith—1. Eye clinic.
Ralph Butler and J. A. Babbitt—2. Ear, nose and throat clinic.

Wednesday

W. J. Creighton and Dr. Smith—1. Eye clinic.

Friday

W. J. Creighton and Dr. Smith—1. Eye clinic.
Ralph Butler and J. A. Babbitt—2. Ear, nose and throat clinic.

GRADUATE HOSPITAL

Monday

R. Butler, G. M. Coates, S. R. Skillern, G. B. Wood and E. B. Gleason—2. Ear, nose and throat clinic.

Tuesday

R. Butler, G. M. Coates, S. R. Skillern, G. B. Wood and E. B. Gleason—2. Ear, nose and throat clinic; demonstration of cases of intercostal neuralgia.

PRESBYTERIAN HOSPITAL

Monday

H. M. Langdon and J. M. Thorington—2. Ophthalmology.

Friday

N. P. Stauffer, W. Cariss and O. R. Kline—2. Otolaryngological operations.

JEWISH HOSPITAL

Wednesday

J. C. Knipe—3. Ophthalmological operations.

Thursday

A. S. Kaufman and R. F. Ridpath—2. Otolaryngological operations.

ST. LUKE'S AND CHILDREN'S HOMEOPATHIC HOSPITAL

Tuesday

Charles B. Hollis and staff—9. Ear, nose and throat clinic.

EPISCOPAL HOSPITAL

Monday

Frederick Krauss—2. Eye clinic.
W. R. Watson—2. Ear, nose and throat clinic.

Tuesday

Harold von Goldberg—2. Eye clinic.

Wednesday

W. R. Watson—1:30. Ear, nose and throat clinic.
A. G. Fewell—3. Eye clinic.

Thursday

C. C. Biedert—1:30. Ear, nose and throat clinic.
Frederick Krauss—1:30. Eye clinic.

Friday

C. C. Biedert—1:30. Ear, nose and throat clinic.
Harold von Goldberg—1:30. Eye clinic.

ST. JOSEPH'S HOSPITAL

Tuesday

George Morley Marshall—9. The Marshall operation for nasal deformity with end results.
A. J. Keenan—3. Otolaryngological operations.

Wednesday

Arthur Wrigley—9. Otolaryngological operations.

Thursday

George Morley Marshall—9. The radical mastoid with end results.
C. T. McCarthy—2. Otolaryngological operations.

Friday

Francis V. Gowen—9. Otolaryngological operations.

CHESTNUT HILL HOSPITAL

Tuesday

John R. Davies—1. Ear, nose and throat clinic.

Wednesday

Benjamin D. Parish—1:30. Ear, nose and throat clinic.

Thursday

John R. Davies—1. Ear, nose and throat clinic.
Carl Williams—2. Ophthalmology.

Friday

Benjamin Parish—1:30. Ear, nose and throat clinic.

COOPER HOSPITAL

(Camden)

Tuesday

A. M. Elwell—2. Otolaryngological operations.

Thursday

A. M. Elwell—2. Otolaryngological operations.

WOMAN'S SOUTHERN HOMEOPATHIC HOSPITAL

Thursday

Gilbert J. Palen, Carroll Haines, H. Bailey Chalfont and Everett A. Tyler—2. Tonsillectomy and adenoidectomy clinic, adults and children under gas anæsthesia.

MISERICORDIA HOSPITAL

Monday

J. E. LOFTUS—2. Otolaryngological operations.

Tuesday

C. T. MCCARTHY—2. Otolaryngological operations.

Wednesday

J. E. LOFTUS—2. Otolaryngological operations.

Thursday

C. T. MCCARTHY—2. Otolaryngological operations.

Friday

J. E. LOFTUS—2. Otolaryngological operations.

UNIVERSITY HOSPITAL

Wednesday

GEORGE FETTEROLF and staff—2. Otolaryngological clinic, operations and demonstration of cases.

Friday

GEORGE FETTEROLF and staff—2. Otolaryngological clinic, operations and demonstration of cases.
T. B. HOLLOWAY—4. Ophthalmological clinic.

PHILADELPHIA GENERAL HOSPITAL

Tuesday

ROBERT J. HUNTER—2. Laryngology.

Friday

L. WALLER DEICHLER—9. Ophthalmology.

WILLS EYE HOSPITAL

STAFF—2, daily. Ophthalmological clinics, operations and demonstration of cases.

STETSON HOSPITAL

Thursday

CARLE LEE FELT—12. Ear, nose and throat clinic.

CHILDREN'S HOSPITAL

JAMES A. BABBITT and associates. Nose and throat clinic.
EDWARD SHUMWAY. Eye clinic.

WOMAN'S HOMEOPATHIC HOSPITAL

Thursday

JOSEPH V. F. CLAY, J. R. CRISWELL, and CHARLES J. V. FRIES, JR.—9. Nose and throat clinic.

JEFFERSON HOSPITAL

Tuesday

LOUIS H. CLERF and staff—9. Bronchoscopy.
F. O. LEWIS and staff—9. Nose and throat operations.

Wednesday

F. O. LEWIS and staff—10. Carcinoma of larynx.
LOUIS H. CLERF and staff—11. Bronchoscopy.

Thursday

LOUIS H. CLERF and staff—9. Bronchoscopy.
F. O. LEWIS and staff—9. Nose and throat operations.

Friday

C. E. G. SHANNON and staff—3. Ophthalmology.

ST. MARY'S HOSPITAL

Tuesday

WILLIAM GRADY—3. Otolaryngology.

Wednesday

F. A. MURPHY—3. Ophthalmology.

Thursday

R. T. M. DONNELLY—3. Ophthalmology.
EDWARD MURPHY—3. Otolaryngology.

NORTHWESTERN GENERAL HOSPITAL

Tuesday

M. S. ERSNER, H. S. WIEDER and M. A. ZACKS—2. Nose and throat clinic.

Thursday

M. S. ERSNER, H. S. WIEDER and M. A. ZACKS—2. Nose and throat clinic.
S. H. BROWN—3. Eye clinic.

ST. AGNES HOSPITAL

Tuesday

BENJAMIN D. PARISH—1. Ear, nose and throat clinic.

Wednesday

GEORGE F. J. KELLY—2:30. Ophthalmological clinic.

WOMAN'S MEDICAL COLLEGE HOSPITAL

Tuesday

MARGARET F. BUTLER—2. Ear, nose and throat clinic.

Friday

MARGARET F. BUTLER—2. Ear, nose and throat clinic.

NORTHEASTERN HOSPITAL

Wednesday

GEORGE E. SHAFFER—2. Sinus disease.
G. A. LAWRENCE—3. Ophthalmology.